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Final Report

RECONNAISSANCE COLOR EVALUATION

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Autometric/Raytheon Company

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13. ABSTRACT

This report documents the testing program conducted by Autometric/Raytheon Company under Contract AF30(602)-4096, RECONNAISSANCE COLOR EVALUATION. The objectives of the program were to determine the relative usefulness of color photography in aerial reconnaissance as compared to panchromatic photography, and to make appropriate specific recommendations for application of color photography in aerial reconnaissance operations. No decisive advantages for either type of photography were found in the test program. Use of color imagery increased the speed of interpretation in both search and analysis tasks to a modest degree, and caused a small improvement in completeness in search tasks where hue was a factor differentiating target from background. However, accuracy of analysis of color photography tended to be lower than that for panchromatic when photo scale was small or marginal in relation to target size. Application of color photography is recommended in reconnaissance situations where color is expected to be a strong clue to desired information, small time savings are significant, and collection of medium to large scale imagery is feasible. Investigations of ways and means of increasing the modest advantages found for color films are also recommended.

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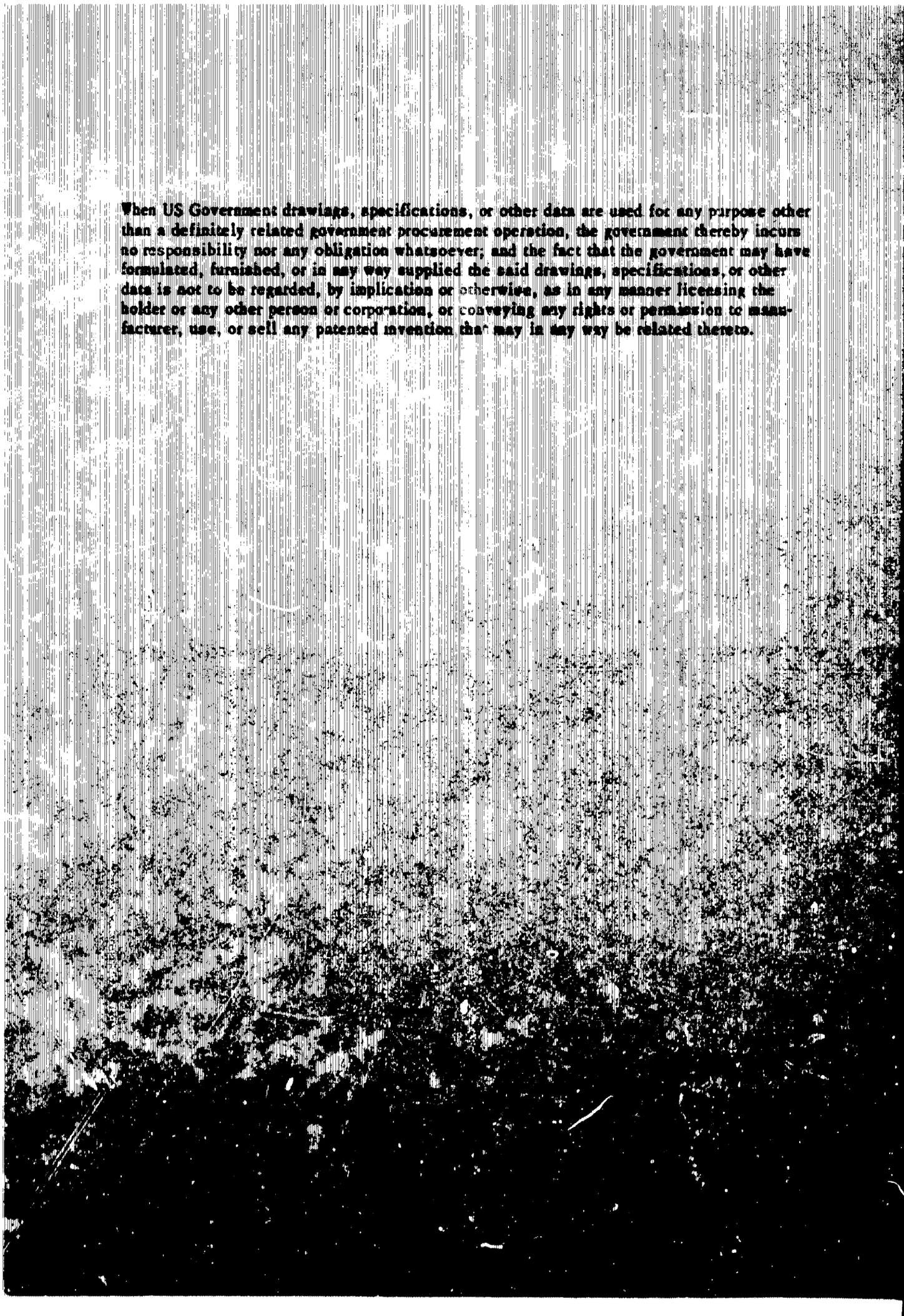
COLOR PHOTOGRAPHY

PHOTOINTERPRETATION



RECONNAISSANCE COLOR EVALUATION

Maurice E. Foley
Milton L. Smith

Autometric/Raytheon Company

AFLC, GAFB, N.Y., 13 Dec 67-73

FOREWORD

Autometric/Raytheon Company, Alexandria, Virginia, is pleased to submit this Final Report on Contract AF 30(602)-4096, Project 6244, RECONNAISSANCE COLOR EVALUATION, to Rome Air Development Center. The report is divided into five sections: Introduction, Imagery and Information Survey, Test Design and Administration, Test Summary, and Conclusions and Recommendations. The Introduction covers the objectives and scope of the program. The next two sections cover the preparatory investigations made and the testing rationale forthcoming from them. Difficulties met are also described, not to reflect negatively on the directing or cooperating organizations, but to give a complete conception of the program. In the Test Summary section, the test conducted and its results are discussed in detail. Conclusions and recommendations based on the test results are included in the final section.

We wish to acknowledge specifically Mr. William R. Dyer, EMIRC, RADC Project Engineer, for his overall guidance of this program and Dr. Wallace Knetz of American Institutes for Research for his professional contributions in test design and data analysis. Though it is impossible to acknowledge personally all those others who aided our efforts, we wish to acknowledge the cooperation of the following organizations which contributed substantially to the success of this program by making film collections available: The Photogrammetric Division of the U.S. Coast and Geodetic Survey, the U.S. Naval Reconnaissance Technical Support Center, the U.S. Army Electronics Laboratory and their supporting contractor, Goodyear Aerospace Corporation, U.S. Army Intelligence Materials Development Office, Cornell Aeronautical Laboratories, the Geographic Systems Division of the U.S. Army Engineer Topographic Laboratory, and the Color Committee of the American Society of Photogrammetry. Acknowledgement is also made of the technical assistance and cooperation readily extended to Autometric/Raytheon in the course of this program by Eastman Kodak Company, the Richards Corporation, and Data Corporation.

This technical report has been reviewed and is approved.

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ABSTRACT

This report documents the testing program conducted by Autometric/Raytheon Company under Contract AF 30(602)-4096, RECONNAISSANCE COLOR EVALUATION. The objectives of the program were to determine the relative usefulness of color photography in aerial reconnaissance as compared to panchromatic photography, and to make appropriate specific recommendations for application of color photography in aerial reconnaissance operations. No decisive advantages for either type of photography were found in the test program. Use of color imagery increased the speed of interpretation in both search and analysis tasks to a modest degree, and caused a small improvement in completeness in search tasks where hue was a factor differentiating target from background. However, accuracy of analysis of color photography tended to be lower than that for panchromatic when photo scale was small or marginal in relation to target size. Application of color photography is recommended in reconnaissance situations where color is expected to be a strong clue to desired information, small time savings are significant, and collection of medium to large scale imagery is feasible. Investigations of ways and means of increasing the modest advantages found for color films are also recommended.

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1. INTRODUCTION

This report documents the work accomplished under Air Force Contract AF 30(602)-4096, RECONNAISSANCE COLOR EVALUATION, between March 1966 and August 1967. Data collected in testing performed under this contract is included, along with conclusions and recommendations based on the test results.

1.1 Initial Program Objectives

The program objectives were originally as follows:

(1) To determine, by appropriate tests of interpretation speed, accuracy and completeness:

(a) Those imagery interpretation operations for which color photographic technology has the greatest potential.

(b) The relative usefulness of color and panchromatic imagery in selected interpretation operations, including rapid screening and target change detection.

(c) The degree to which the usefulness of color imagery is influenced by mission, collection, and exploitation parameters, including film emulsion, imagery scale and target aspect angle.

(2) To formulate specific conclusions and recommendations for color photographic technology applications

to strategic and tactical aerial reconnaissance operations.

1.2 Scope Of The Program

To accomplish the stated objectives a three-part program was planned: a survey of imagery and information applicable to the problems of color photo reconnaissance, a test of the comparative values of panchromatic and color aerial photography under the stress of selected independent variable factors, and an investigation of the potential of color inducement techniques in aerial reconnaissance imagery interpretation.

After preliminary investigation, it was found that a meaningful treatment of color inducement technology was beyond the scope of this contract, and, with the concurrence of the Air Force technical monitors, the third element of the program was discontinued.

In pursuing the proposed imagery survey it was determined, after considerable effort, that the amount and variety of comparable panchromatic and color aerial photography available to the Air Force, which was to provide all test imagery under this contract, would not support the proposed test effort. The testing finally conducted, with the approval of technical monitors, was predicated on the available imagery, and differs significantly from that originally proposed. However, the program objectives were satisfied to the maximum degree allowed by the available imagery. The measures taken to circumvent the limitations of the

available imagery, the shifts in program emphasis accepted when necessary, and the results of the operations undertaken are detailed in the following sections of the report.

2. IMAGERY AND INFORMATION SURVEY

2.1 Operations

2.1.1 Literature Search

A literature search was made to insure that all resources were thoroughly investigated and that proposed tasks had not been accomplished in the work of others. No detailed analysis of the literature was undertaken, nor was it the intent of the search to produce a bibliography of reconnaissance color development. Defense Documentation Center bibliographies were reviewed and copies of significant reports were ordered for study. In addition, the Data Base at RADC was searched and copies were made of pertinent data. Of particular interest throughout the literature search were the film catalogs of all programs for which panchromatic and color imagery had been acquired. Significant programs were noted for investigation and subsequent imagery search.

A trip was made to Eastman Kodak in Rochester to discuss the status of aerial color film development and to seek advice on devising techniques for quality control of color imagery duplication.

These efforts yielded the following information.

(a) Few studies comparing color and panchromatic

films had been conducted within the past five years.

(b) Proposed tests would not duplicate any prior work.

(c) Present technology cannot provide quality controls for color film reproduction which would ensure exact rendition of tone and hue from original to duplicate, nor can differences between them be effectively quantified.

2.1.2 Imagery Search

Since no imagery acquisition program was provided in direct support of the proposed tests, it was necessary to use photography already acquired on other programs. Such imagery was scattered at the film libraries of several government agencies, and the extent of available, usable imagery was unknown. In addition, ground truth and collateral information were also required to provide control of proposed test parameters.

On the basis of the literature search, the programs listed in Table I were selected as having the greatest potential for providing imagery appropriate to the needs of the Reconnaissance Color Evaluation testing program. In addition, U.S. government mapping agencies and the American Society of Photogrammetry in the Washington, D. C., area were selected as possible sources of photography.

TABLE I

Programs Investigated as Possible
Sources of Test Imagery

PROGRAM	COGNIZANT AGENCY
Project Tropican	Rome Air Development Center Research and Technology Division
Project Art	U.S. Army Electronics Laboratories U.S. Army Electronics Command
Project Argos	Interservice Imagery Acquisition Task Group
Project Array	Joint Army/Air Force Imagery Acquisition Task Group
Project Arras	Joint Army/Air Force Imagery Acquisition Task Group
Project Road	Joint Army/Air Force Imagery Acquisition Task Group
Project Snowfex	Joint Army/Air Force Imagery Acquisition Task Group

A team of experienced image interpreters visited each facility which indicated a willingness to release imagery for test purposes. This team examined at each library all film which appeared to have potential for the testing program. In all, more than 10,000 feet of film were screened. Rolls selected during the initial screening were shipped to the contractor's facility at Rome, New York, for more detailed analysis and more discriminating selection.

To meet the conditions imposed by the predetermined test parameters a collection condition matrix was devised to organize the collected imagery during analysis for possible use as stimulus material. Initial restrictions imposed on imagery searchers by this matrix were as follows.

(a) Only original flight records would be collected for duplication.

(b) Panchromatic and color would be concurrent and congruent in regard to the factors considered in the matrix.

(c) Comparable images would have similar formats, scales, and aspect angles.

The matrix called for sets of comparable panchromatic and color imagery showing the following variations deemed to be significant:

Format	- Three types
Scale	- Four conditions
Time of acquisition	- Two conditions
Field of view	- Two conditions
Target size/density	- Three conditions.

Thus, 144 sets of imagery (or a minimum of 288 frames) were required to fill each matrix. Coverage of six categories of tactical targets were desired: vehicles, emplacements personnel, animals, shelters, and miscellaneous targets.

When it was determined that panchromatic and color imagery acquired by similar systems at the same point in time and space was not readily available in adequate supply an alternate plan was considered. To save substantial travel and manpower expenditures, and to provide exact duplication of test image spatial relationships, an experiment was performed duplicating original color imagery on panchromatic film emulsions to provide complementory black and white photos. Appendix I describes this experiment which demonstrated that black and white tonal values produced in the laboratory from color originals could not be made to match those acquired in flight on panchromatic films. Since it was felt that valid laboratory simulations could not be produced without considerable development, the decision was made to proceed with the comprehensive imagery search.

Reproduction of all selected imagery was accomplished by RADC. Panchromatic film was reproduced in the RADC

photographic laboratory and color film was reproduced under contract by another contractor. In all cases precise quality control measures were called for to insure maximum image quality of duplicate images. For the color transparancies "maximum quality" was designated as nearest possible duplication of density, tone, and hue.

The scheme devised for the collection of stimulus imagery involved four steps of increasing refinement:

(a) On-site screening at film libraries for general quality, and general congruity of color and panchromatic images.

(b) Initial target analysis at contractor's facility to select appropriate portions for duplication.

(c) Quality evaluation and detailed target and collection condition analysis of duplicated materials.

(d) Selection of final test frames and construction of scoring overlays.

Since only original imagery was to be considered for duplication, it was necessary to screen materials at their repositories because holders were reluctant to release large quantities of original records. Further, in several cases it would have been

highly impractical to ship the total coverage acquired for a given project.

Limitations posed by customer resources for color reproduction and by common-sense economy required an initial analysis of all rolls of film sent to the contractor facility to eliminate needless reproduction of materials. On the other hand, custodians of the original imagery would release film only for a period of 30 days or less. Since color reproduction was performed by another contractor at another location, the bulk of this period was needed for duplication. In no case was color film reproduced and returned for quality comparison with originals in less than 20 days. It was impossible, therefore, to perform a detailed target analysis prior to reproduction.

Immediately upon the return of duplicated materials a subjective quality evaluation was made of all duplicate color transparancies by comparing them frame-by-frame with the original records. Hue and tonal values were carefully matched against the original film for accuracy of duplication. Brief descriptive evaluations were prepared for all duplicated color materials prior to returning the original film to its custodian.

Detailed image analysis of all duplicated materials completed the third step in test image selection. Targets or target equivalents were annotated and enumerated, rough overlays were made, and notes were recorded on potential testing tasks for each portion of imagery. Selected imagery was classified and

assigned a position in predetermined collection condition matrix.

The final step was the selection of frames to be used as test materials and the designation within those frames of target stimuli for which interpreter responses would be measured. The chosen frames were then arranged into numbered test packets and scoring aids such as overlays and grids were constructed as appropriate.

2.2 Results Of The Imagery Search

The net result of the operations described above was to make it clear before the final step described above that the volume and variety of appropriate aerial imagery available to the Air Force was not sufficient to allow completion of testing in the form originally proposed. As the imagery search progressed, it became evident that most of the imagery of acceptable quality fell within a very few blocks of the collection condition matrices. For example, significant differences in times of day, aspect angle, and field of view were not found in abundance, if at all. For in the category of vehicles, which were the most commonly imaged target type, only 20 of the 144 matrix addresses were filled by the end of the photo search phase. Other target matrices had as few as six entries.

Specifically, the imagery was deficient in four ways:

(1) Very little concurrently-collected panchromatic and color photography existed. Also, upon

examination, very little of the apparently comparable panchromatic and color imagery was, in fact, congruent or nearly so with respect to the selected test parameters (format, target aspect angle, target-to-background relationship, target image density and size, and time of collection).

(2) Coverage of a sufficient variety of tactical and strategic military targets was lacking.

(3) Comparable coverage of actual military targets was not varied enough with regard to the selected parameters to fill the matrix and allow testing of the effect of change in particular factors. Variation which did occur was not systematic.

(4) Documentation of ground situations represented in the available coverage was lacking in most cases.

In response to the basic shortage of appropriate test photography, the approach to test design was reversed. Rather than continuing to search for photography to fill the predetermined testing matrix, it was decided to evaluate the available comparable coverage and build a test based on its contents.

To deal with the particular imagery deficiencies outlined above a number of specific changes were made.

(1) As an alternative to concurrently collected panchromatic and color imagery (which would be

comparable in all respects), a very rudimentary, but operationally realistic, comparability was substituted. Considerations of film emulsion, aspect angle and time of collection were dropped, because significant variations in these areas were almost totally lacking in the available imagery. Stress was laid on similarity of coverage and comparable relationships between format and the size and density of target images in both color and black-and-white photography. In several cases where only desirable color imagery existed, efforts were made to have comparable coverage collected on a no-cost basis.

(2) To overcome the lack of military target coverage, equivalent non-military targets were searched out. The judgment of equivalency was based on frequency of occurrence, image size and density in relation to format, and target-to-background relationships. A consensus in regard to equivalency was required among the experienced interpreters constructing the test.

(3) Because a classic test of the influence of predetermined independent variables was clearly impossible, the focus of the test was shifted. It was decided to emphasize a variety of interpretation

tasks rather than variations in imagery characteristics. Imagery on hand was found to be sufficient for this purpose.

(4) Because of the lack of ground information on selected military and non-military targets, multiple analysis of test imagery leading to a consensus interpretation was carried out. Each piece of potential test imagery was analyzed by at least three interpreters. Only imagery on which a consensus interpretation could be produced was included in the test.

By these measures there was constructed a test deemed, under the circumstances, to be extensive and incisive in its coverage of color reconnaissance problems.

3. TEST DESIGN AND ADMINISTRATION

The types of problems presented to interpreters in this test program were determined by three considerations:

(1) The basic tasks which make up the analytical work of an operational interpreter.

(2) The characteristics of color imagery which differentiate it from panchromatic imagery and which would give rise to any advantages or drawbacks in its use instead of panchromatic imagery.

(3) The content and characteristics of the available imagery.

3.1 Operational Considerations

The tasks which are the components of any specific photo-analytic assignment were defined for purposes of this test as the following:

(1) Searching for and counting recognizable target signatures.

(2) Analyzing complex images and discriminating between like signatures by observation, comparison, and mensuration.

(3) Delineating boundaries not clearly defined by the characteristic signature of the target.

(4) Plotting items found in imagery on another graphic representation of the same geographic site.

It was recognized that these tasks are rarely performed operationally in isolation from one another, but the effort was made to devise realistic test problems which would highlight each of the tasks and perhaps illuminate the effect of the use of color imagery on its performance.

3.2 Technical Considerations

The characteristic of color photography which is most apparent to the analyst is, of course, the color emulsion's

ability to record target hue as well as value with some degree of accuracy. A second is the relatively coarser grain structure of color emulsions vis-a-vis panchromatic emulsions normally used in aerial reconnaissance and the lower spatial resolution associated with it. A third characteristic, relatively less apparent to the analyst, but nevertheless important in certain reconnaissance situations, is the relatively higher illumination requirements of color emulsions as compared to black-and-white emulsions which restrict the light conditions under which acceptable color imagery can be collected. It was felt that, from the analyst's point of view, the advantages or disadvantages accruing to the use of color photography would probably be traceable to these characteristics. Attempts were made in designing the test to find situations wherein these characteristics would play an important part.

3.3 Imagery Considerations

Consideration of the characteristics of the available imagery unfortunately served to limit somewhat the treatment in this test of both analytical tasks and distinctive characteristics of color films. Lack of long continuous samples of comparative color and panchromatic imagery precluded problems involving the rapid scanning and plotting work characteristic of immediate post-collection operational interpretation. All problems involved finally, relatively detailed analysis of small amounts of film. It was found also that there were no acceptable samples

of film collected at other than optimum times of day. This precluded testing of the effects of marginal target illumination. On the positive side, the available imagery included a useful variety of target backgrounds. Though hoped-for records of seasonal changes over like sites were not found, the collection was sufficient to provide test imagery with a wide variety of natural and cultural settings. Sets of test imagery showing tactical military targets were in short supply, but non-military "targets" did appear which allowed formulation of problems judged to be equivalent to those of the operational analyst working with military targets. In addition, strategic targets were represented in adequate number and variety in the available imagery to allow some freedom of selection.

3.4 Test Problems and Tasks

It proved possible to derive from the various combinations of backgrounds and actual or constructive targets a test consisting of eight problems, each represented by two typical tasks. The doubling of each type of problem served to provide some check of the quality and validity of individual tasks, as well as to enlarge the base from which test data were derived and to make a varied and interesting test. For each task there was available comparable panchromatic and color photography sufficient for stereo as well as monocular analysis. All problems and tasks were examined carefully in a pre-test by two experienced interpreters. Revisions in the matter, scope and time

limits were made as recommended by these analysts. The tasks and the characteristics of the photo coverage for each one are given in detail in later sections of this report dealing with the specific problems and the test results for each.

3.5 Testing Environment

Each test subject was given the test in isolation. He was attended by a test monitor whose job it was to present and explain tasks in random sequence, record subject responses to each, and keep time. This arrangement served to standardize both administration and data collection, to allow the subject closer concentration on the test imagery, and to shorten overall test administration time. Subjects viewed all test imagery in positive transparent form on horizontal light tables. Viewing devices used were standard 2X and 4X folding stereoscopes and 7X tube magnifiers. Measurement was done with .001' scales and reticles.

3.6 Test Administration

The test was administered to twenty-four subjects, all imagery analysts employed by Autometric/Raytheon Company. Before beginning the test each subject filled out the subject biography sheet included in Appendix A. General instructions for the test were given, along with a preliminary problem to familiarize the subject with testing and recording procedures. The sixteen tasks of the test proper were then presented in carefully randomized order. Type of film (color/panchromatic) to be viewed in each

problem and mode of viewing (monocular/stereoscopic) were also pre-determined to guarantee an even distribution of film type and viewing mode for each subject and problem. If, for instance, the first task of a given problem was presented to a subject for monocular analysis using color film, the same subject would later be presented with the second task for that problem and asked to perform stereoscopic analysis using panchromatic photography. Each problem situation was presented according to the script included in Appendix A. A standard time limit for each problem was stated. These limits were pre-determined to be moderately generous, and were used to make subjects aware that time was a test factor, rather than to limit working time. Subjects were asked not to guess at responses, but to decline to make a response if they felt image quality would not allow accurate analysis. By design, all subject responses were made verbally to the test monitor, who recorded the data on the prepared form, which is included in Appendix A. Data recorded included order of task presentation, film type/viewing mode, subject responses, elapsed time for whole problems and significant segments, and confidence in response accuracy and/or completeness stated as one of seven levels ranging from complete lack of confidence to certainty. (Seven levels were proposed in order, hopefully, to avoid easy quantizing of the response and possible bunching of responses around common numerical values.)

Following the completion of all testing, the responses of each interpreter were scored. Raw scores and scores adjusted for time consumption were calculated for each task. In addition, types of errors -- commission, omission or failure to respond -- were differentiated. All these data, together with the raw test responses, were recorded on test score sheets of the type included in Appendix A and passed to American Institutes for Research for thorough analysis under subcontract to Autometric/ Raytheon Company.

4. TEST DATA ANALYSIS

4.1 Experimental Design

Separate analyses were desired for each of eight types of reconnaissance problems. Corresponding panchromatic and color imagery were assembled for two different, but reasonably equivalent, tasks per problem. This assortment of imagery permitted the use of a balanced incomplete blocks experimental design[1], with two two-level factors: Color (panchromatic vs. color imagery) and Viewing Mode (mono vs. stereo).

Each of twenty-four subjects performed the prescribed interpretations for all sixteen tasks, having been assigned randomly, for each task, one of the four possible combinations of pan-color and mono-stereo, within the following constraints:

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[1] Brownlee, K.A., Industrial Experimentation, 4th American Edition, Brooklyn: Chemical Publishing Co., 1953.

each level of both factors was employed once only per subject for the two tasks representing one of the eight problems; and across all subjects, each task was assigned equal numbers of the four factor-level combinations. As a result, for each of the eight problems a subject was observed under both levels of Color and of Viewing Mode, but under only two of the four possible factor-level combinations. In addition, the sixteen tasks were presented to each subject in a unique random order.

The design which was employed permits the statistical evaluation of the effects of Color and of Viewing Mode upon the obtained scores, by means of the Analysis of Variance technique. This evaluation is reliable at the test and problem levels, but not for individual tasks. Because of the presence of incomplete blocks in the design, the effects of the interactions of Color and Viewing Mode cannot be evaluated. (The use of four equivalent target tasks per problem would have permitted a complete-block design with resulting evaluation of these interactions, but the amount and variety of available imagery precluded this approach.)

It should also be noted that, in the Analysis of Variance for the balanced incomplete blocks design, the effect of factor interactions upon the data -- to the extent that they exist -- is to provide an overestimate of "error" variance. This, in turn, increases the conservatism of the statistical tests of main factor effects beyond that which is intended -- i.e., decreases the chances of obtaining statistically significant

findings for an actual factor effect.[2] However, in the experiment, there is no prior evidence to suggest strong interactions of Color and Viewing Mode upon interpreter performance, and thus it was expected that the most detrimental effect of the shortcoming in the design would be to mask out the weaker Color or Viewing Mode effects which, although statistically significant, would represent low magnitude differences in performance scores.

4.2 Performance Scoring and Analysis

Five methods of scoring reconnaissance performance were employed in this study. The scores were calculated separately for each of the sixteen tasks.

Terms employed in the scoring formulae were defined as follows:

- cpr = number of correct possible responses for a problem
- errors = number of targets missed in search problems (errors of omission); number of misidentifications and non-responses in analysis problems
- fa = "false alarms" -- number of misidentifications in search problems
- et = elapsed time for subject performance

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[2]McNemar, Q., Psychological Statistics, Second Edition, New York: Wiley, 1955.

at = maximum allowed time for performance on a target area.

The scores were:

$$\text{Raw Score} = 100 \times \frac{\text{cpr} - \text{errors} - \text{fa}}{\text{cpr}}$$

$$\text{Adjusted Score} = \text{Raw Score} + 100 - \left(100 \times \frac{\text{et}}{\text{at}}\right)$$

$$\text{Accuracy Score} = 100 \times \frac{\text{number of correct responses made}}{\text{total number of responses made}}$$

$$\text{Completeness Score} = 100 \times \frac{\text{number of correct responses made}}{\text{cpr}}$$

$$\text{Speed Score} = 100 - \left(100 \times \frac{\text{et}}{\text{at}}\right) = 100\left(1 - \frac{\text{et}}{\text{at}}\right)$$

Subjects were required to express their confidence in their responses on a seven-point scale ranging from A (none, guess) through G (certain). For the data analysis, these scores were converted to equal-interval weights of values zero through one. The weights were applied to the basic raw, adjusted (raw component), accuracy and completeness scores, to obtain a parallel set of confidence-weighted acores. The use of confidence weights was an effort to compensate for the unavoidable artificiality of the experimental situation, in which subjects can be expected to report more low-confidence material than in many operational situations.

5. SUMMARY OF TESTING AND ANALYSIS

In the following pages the test and the test data are analyzed in detail. The first sections of this analysis include general information on the test and its findings. The succeeding sections each cover one of the eight problems of the test and the two tasks presented to subjects as typical of that problem. In each the problem and tasks are described and the findings listed. Then the reliability of the tasks, the validity of the collected data and the implications of the results are discussed. Each section also contains graphic representations of the findings developed from the figures included in Appendix B, Test Analysis Data.

5.1 General Information

Of the eight problems included in the test, the first four center on aspects of searching, and the last four on analysis. The final problem is one of target delineation, here considered as a special case of analysis. The search problems were designed to focus on completeness, minimizing analytical work and questions of accuracy. Imagery scales and target signatures selected were such as to reduce target identification errors to the minimum. Therefore, accuracy was assumed, and only those targets reported in excess of the number known to be present were scored as errors of commission, or "false alarms". The reverse was true of the analysis problems. Problems of completeness were minimized, and questions of accuracy underscored. Targets were annotated and desired responses specifically requested in most

cases, so differences between accuracy and completeness in the analytical problems (4 through 8) are indications of refusals to respond on the part of subjects who considered the imagery inadequate for the particular task.

5.2 General Findings

Across the test as a whole, interpretation of color imagery was found to be significantly faster, statistically, than interpretation of panchromatic films. No statistically significant differences between color and panchromatic interpretation were found in regard to accuracy and completeness, though minor differences in completeness, in favor of color, were recorded (see Figure 1).

Again considering the test as a whole, no significant differences in any aspect of performance were found between monocular and stereoscopic interpretation.

It is also worth noting that, overall, weighting of scores for subject confidence in performance brought about no significant shifts in relationships between the types of interpretation compared (see Figure 2 and Table II).

SUMMARY OF BASIC MEAN SCORES

PROBLEMS 1 THROUGH 8

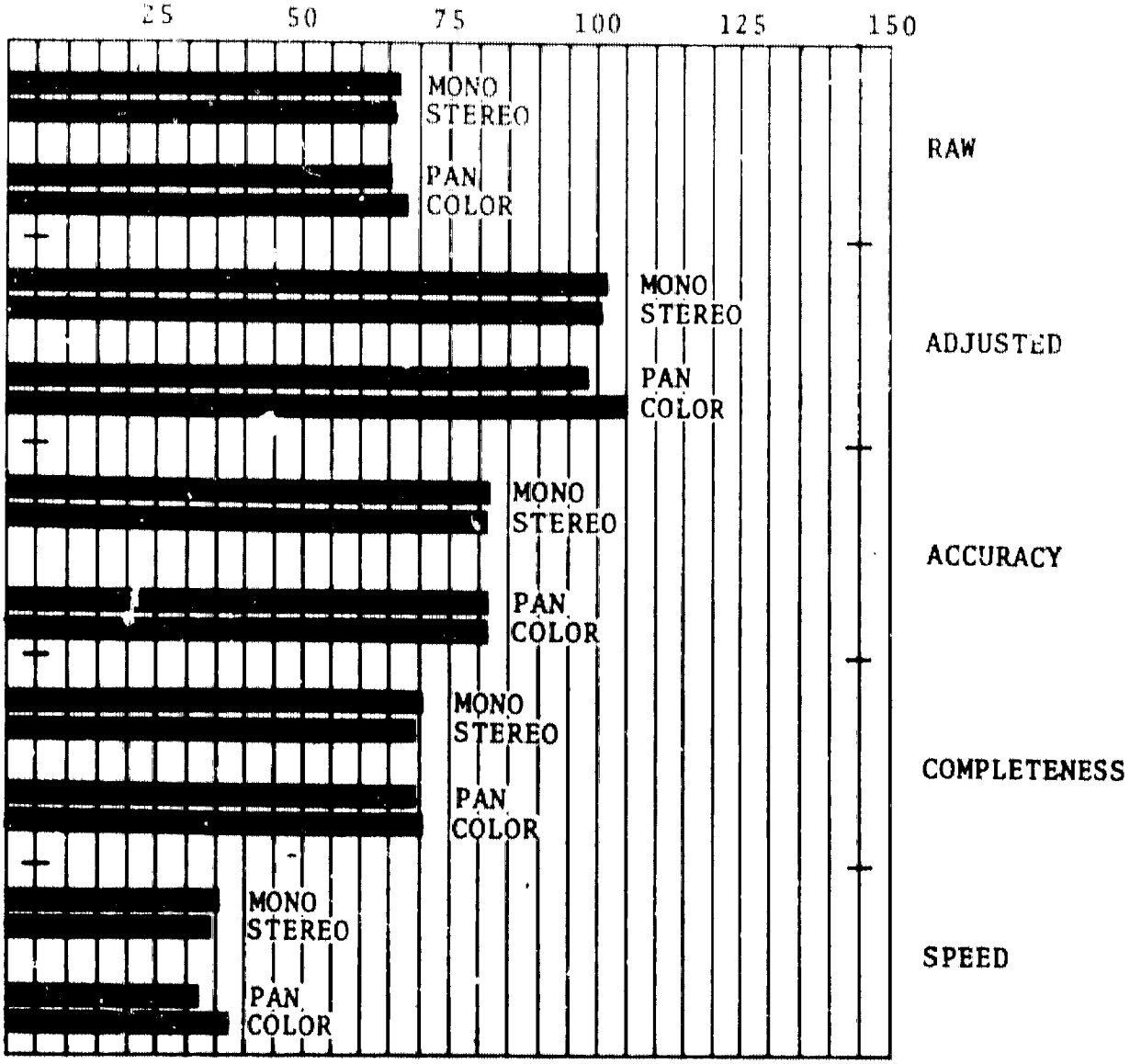


FIGURE 1

SUMMARY OF CONFIDENCE-WEIGHTED MEAN SCORES

PROBLEMS 1 THROUGH 8

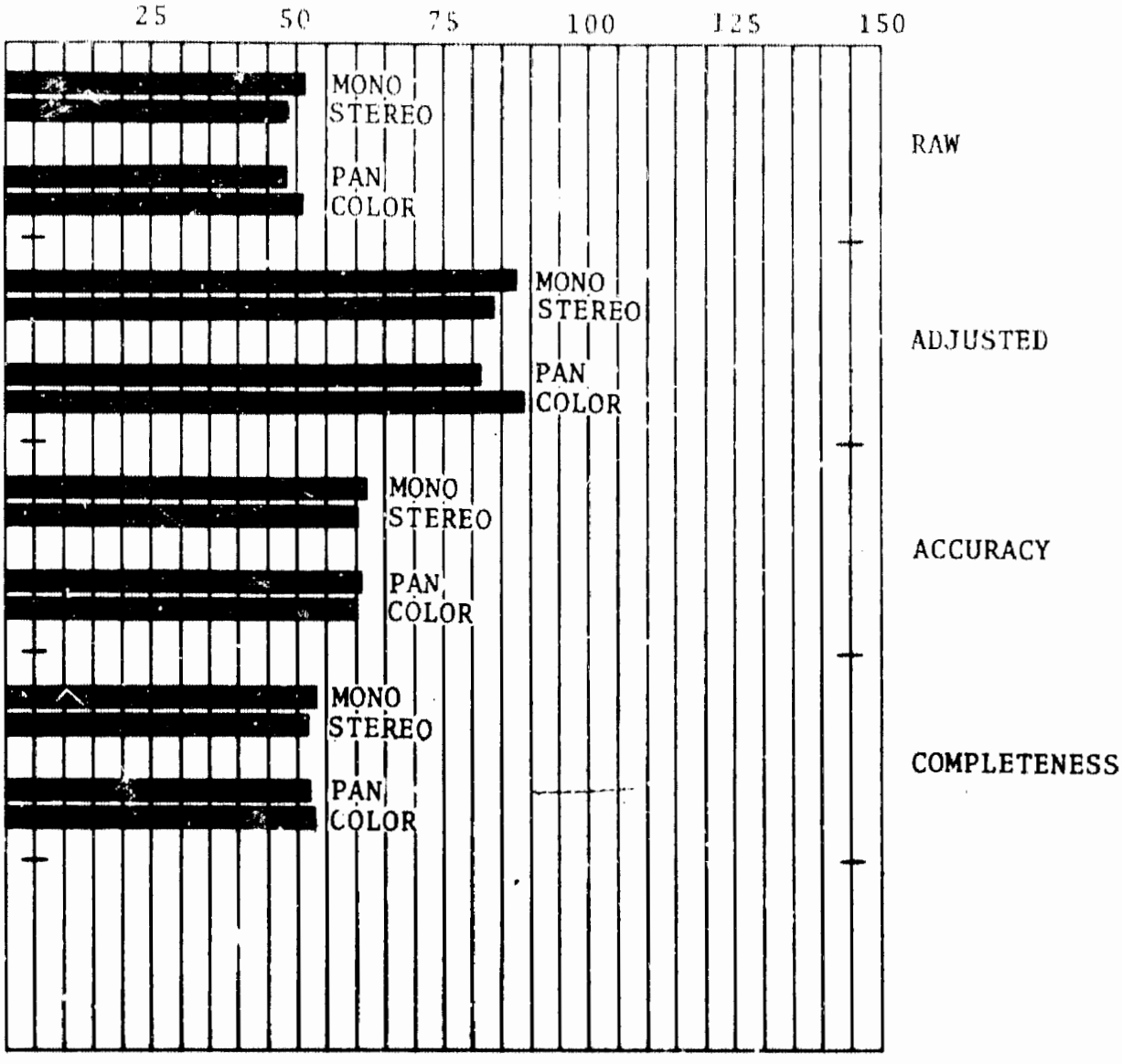


FIGURE 2

SUMMARY OF SIGNIFICANT DIFFERENCES

TABLE II

VIEWING MODE EFFECTS

Prob.	Score	Mono Mean	Stereo Mean	Diff.	F Ratio	df	p
5	Adjusted - Basic	95.44	81.01	14.43	4.2782	1,45	<.05

COLOR EFFECTS

Prob.	Score	Color Mean	Pan Mean	Diff.	F Ratio	df	p
Overall 1 thru 8	Speed - Basic **	37.51	32.69	4.82	4.3428	1,381	<.05
3	Adjusted - Basic	127.37	107.67	19.70	5.0492	1,45	<.05
	Conf. Wtd.	104.66	83.85	20.81	5.1509	1,45	<.05
3	Comp. - Basic	82.62	72.57	10.05	4.0316	1,45	*
	Conf. Wtd.	59.74	48.33	11.41	4.1282	1,45	<.05
5	Adjusted - Mean	108.35	92.82	15.53	6.5542	1,45	<.05
	Conf. Wtd.	96.47	79.98	16.49	5.5880	1,45	<.05
5	Speed - Basic **	38.43	28.58	9.85	5.3507	1,45	<.05

---

* F ratio fails to attain .05 significance by 0.03

** Confidence weights not applied to speed scores

5.3 Problem 1. Search: High Target Density/Urban Background

This problem was one of finding many targets of one type against an urban/suburban background and counting them accurately. It focused on the influence of film type and mode of analysis on the orderliness, completeness and speed of the search operation. The analyt' l aspects of the problem were reduced to a minimum by directing the search toward a single, easily-recognized target type which appeared many times in the imagery at a scale moderate in relation to target size. The background was characterized by the broken geometric patterns of line, tone and texture typical of culturally developed areas.

5.3.1 Task 1

The subjects were asked to find and count all the hard-surfaced multiple-vehicle parking lots imaged in vertical coverage of Annapolis, Maryland at a scale of 1/20,000. Seven 9" frames of either panchromatic or color imagery were presented. Both films covered the same targets on nearly congruent flight lines, so coverage was comparative, except for mild seasonal changes which were judged to be insignificant to test target interpretation. Twenty-five targets were imaged, and the subject was asked to report each ten as counted and a final total within 20 minutes. Target counts and reporting times were recorded along with the subject's confidence in the completeness of his final count.

5.3.2 Task 2

The subjects were asked to count self-propelled vessels larger than tugs shown in verticle coverage of the harbor of Bayonne, New Jersey at a scale of 1/165,000. Three 70mm frames of either panchromatic or color imagery were examined by the subjects, but the test area was that covered by the center frame only. The samples were collected concurrently. Forty-six targets were imaged. The subject was asked to count them in groups of ten and report a final count and his confidence in its completeness within 10 minutes.

5.3.3 Findings

At the problem level, no statistically meaningful differences in performance were found in comparing basic mean scores of pan and color or mono and stereo interpretations (see Figure 3). Confidence-weighted mean scores paralleled basic means very closely (see Figure 4). No reversals occurred.

5.3.4 Discussion

Though the test data is not reliable below the problem level, it should be noted that minor reversals between color and pan analyses were recorded in the results of Tasks 1 and 2. One cause of this may have been the poorer quality (graininess) of the smaller scale Task 2 color imagery as compared to the Task 1 imagery. However, the validity of neither task seemed to be harmed. Very high mean accuracy scores at the task and problem levels and the closeness of mean raw and completeness scores

indicate that the tasks functioned as designed. Confidence seemed to reflect actual performance fairly accurately in both tasks.

It may be speculated that, because the urban background of the imagery in this problem was broken in pattern, color clues offered nothing useful to the analyst or perhaps operated as a mild confusion factor in his attempts to separate targets from background.

PROBLEM NO 1. SEARCH: HIGH TARGET DENSITY/URBAN BACKGROUND

BASIC MEAN SCORES

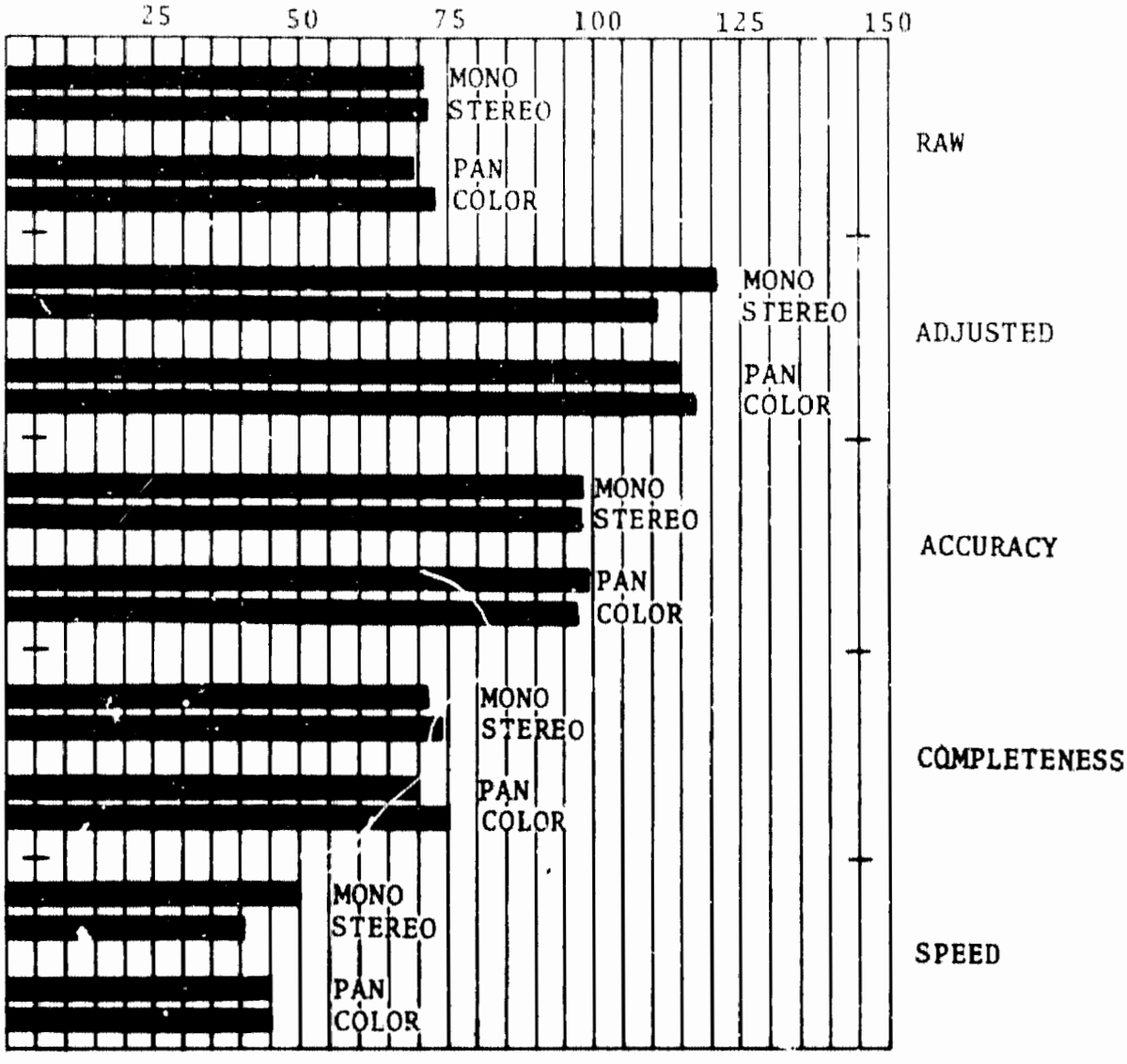


FIGURE 3

PROBLEM NO 1. SEARCH: HIGH TARGET DENSITY/URBAN BACKGROUND

CONFIDENCE-WEIGHTED MEAN SCORES

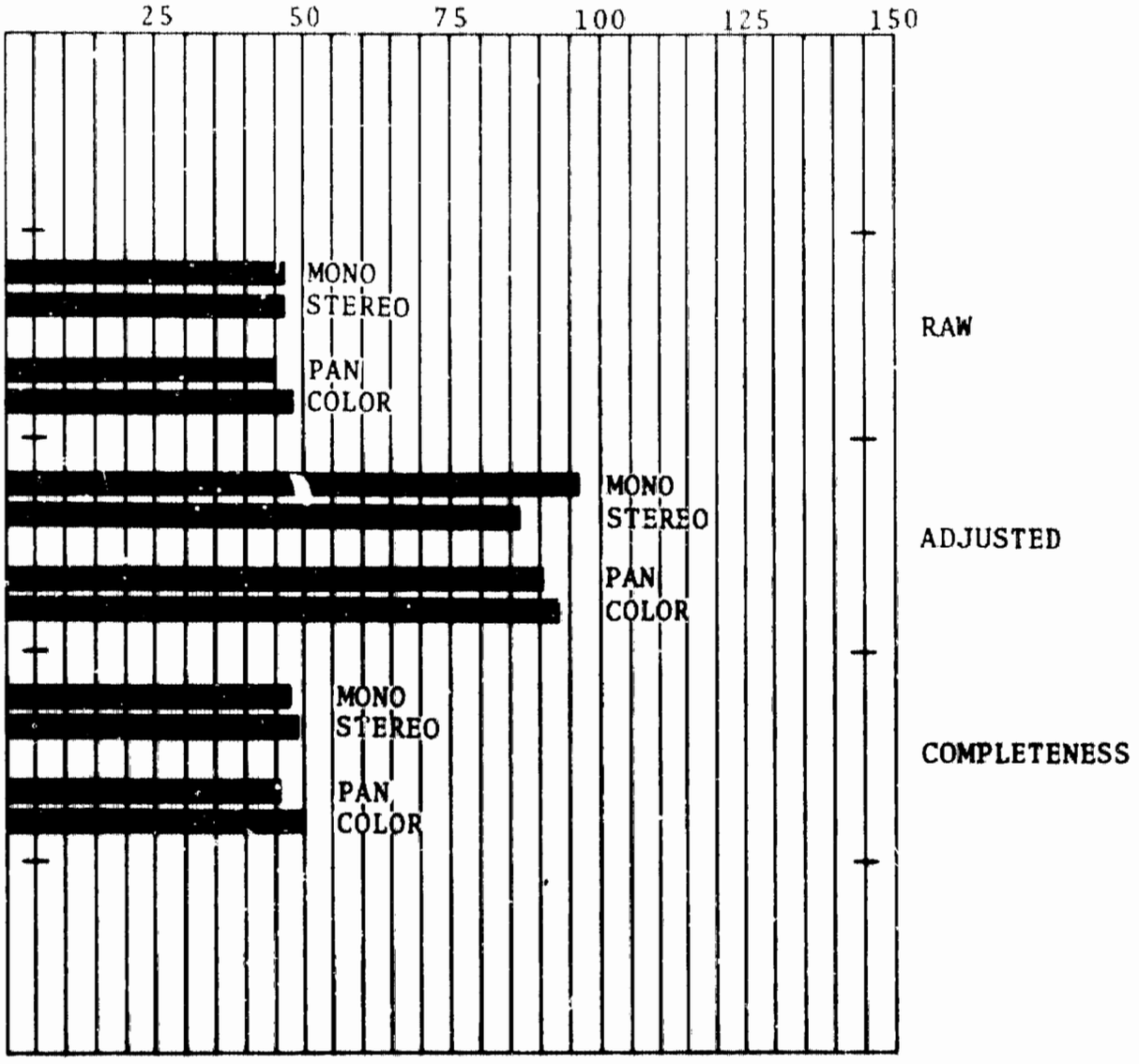


FIGURE 4

5.4 Problem 2. Search: Low Target Density/Urban Background

The primary work in this problem was finding rare or isolated targets in an urban/suburban environment. The targets were easily recognized and well-imaged so that difficulty of identification was minimized. The object was to measure the thoroughness and speed of the search made using each of the test films.

5.4.1 Task 3

The subjects were asked to find and count seven different target types in the area of Annapolis, Maryland. The imagery consisted of fourteen 9" vertical panchromatic frames or ten 9" vertical color frames, both strips at a scale of 1/40,000. Flight lines were near-congruent, so the imagery was comparable except for minor seasonal variations. A total of eight targets were imaged in six of the seven categories requested, the one category not represented having been added as a confusion factor. The categories included Nike sites, underground storage areas, and dry docks among other targets of like size. A simple recognition key was distributed which showed salient features of the requested targets. Target counts in all categories were recorded along with completeness confidence, and 40 minutes were allowed for completion.

5.4.2 Task 4

Subjects were asked to detect and count within 20

minutes all road, street and highway construction sites shown in vertical coverage of a suburban area of San Francisco at 1/40,000 scale. Twelve frames of concurrently exposed 70mm panchromatic or color film made up the test sample. Eight targets were imaged. Test monitors recorded each subject's total count, elapsed time and confidence of completeness.

5.4.3 Findings

Mean scores at the problem level showed very similar results for pan and color analysis and mono and stereo viewing of the problem imagery (see Figure 5). No statistically significant variations occurred. The very minor differences which were recorded were further dampened when scores were weighted for confidence (see Figure 6).

5.4.4 Discussion

As in Problem 1, it may be that the broken urban background reduced the significance of color in finding targets without unique color signatures.

The relationships between means for the variables within each task were closely parallel to those for the problem overall, indicating that the individual tasks were reliable. However, subjects did noticeably less well on all aspects of Task 3 than Task 4, regardless of film type or mode of analysis. Likewise, confidence in completeness was lower across all variables for Task 3 than Task 4, though unnecessarily so. This lower performance and even lower confidence may be attributable to the fact

that Task 3 involved several types of targets while Task 4 involved only one. Task 3, therefore, may have demanded more skill and background than Task 4, or may have caused some confusion by its relative complexity.

PROBLEM NO 2. SEARCH: LOW TARGET DENSITY/URBAN BACKGROUND

BASIC MEAN SCORES

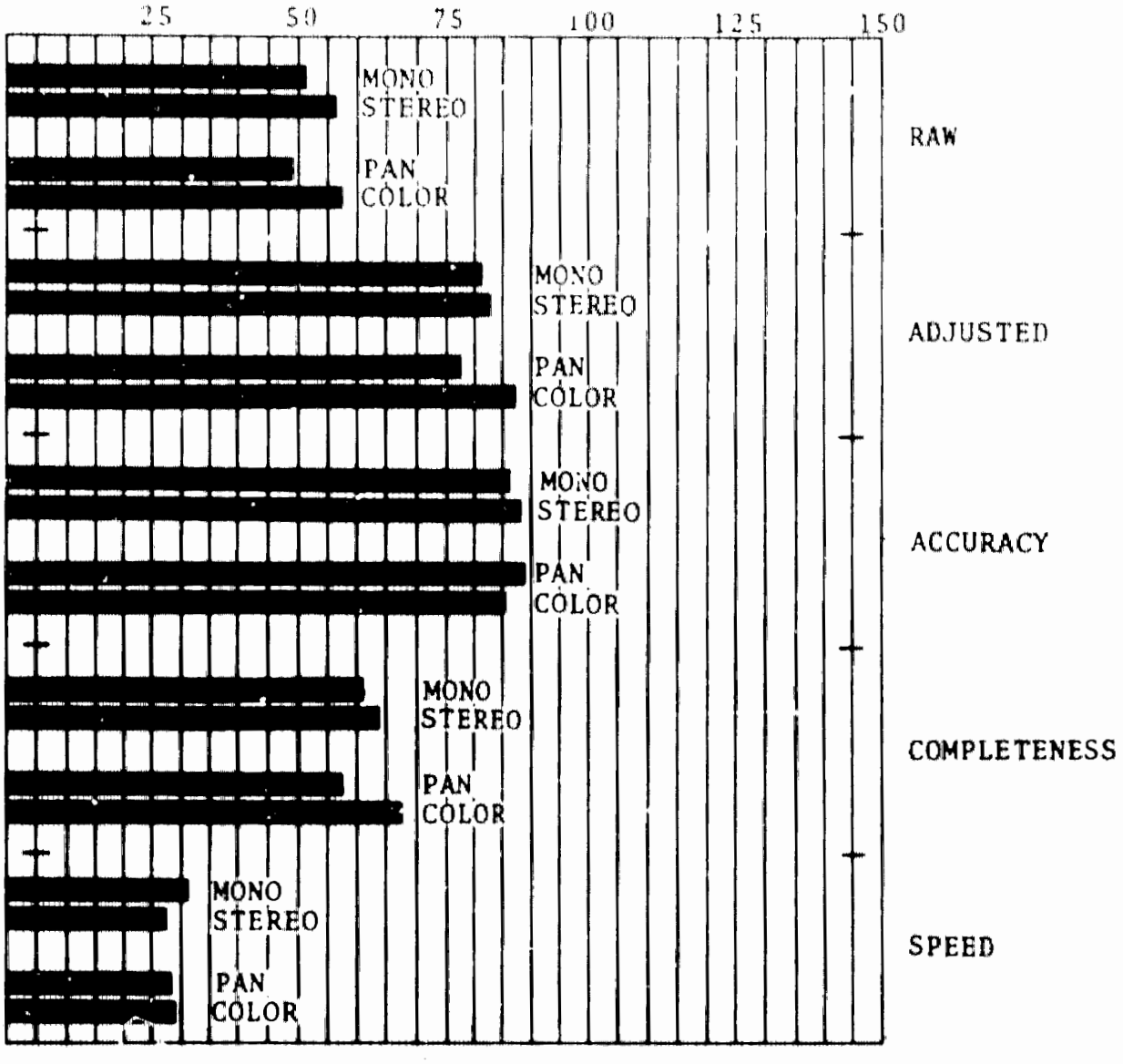


FIGURE 5

PROBLEM NO 2. SEARCH: LOW TARGET DENSITY/URBAN BACKGROUND

CONFIDENCE-WEIGHTED MEAN SCORES

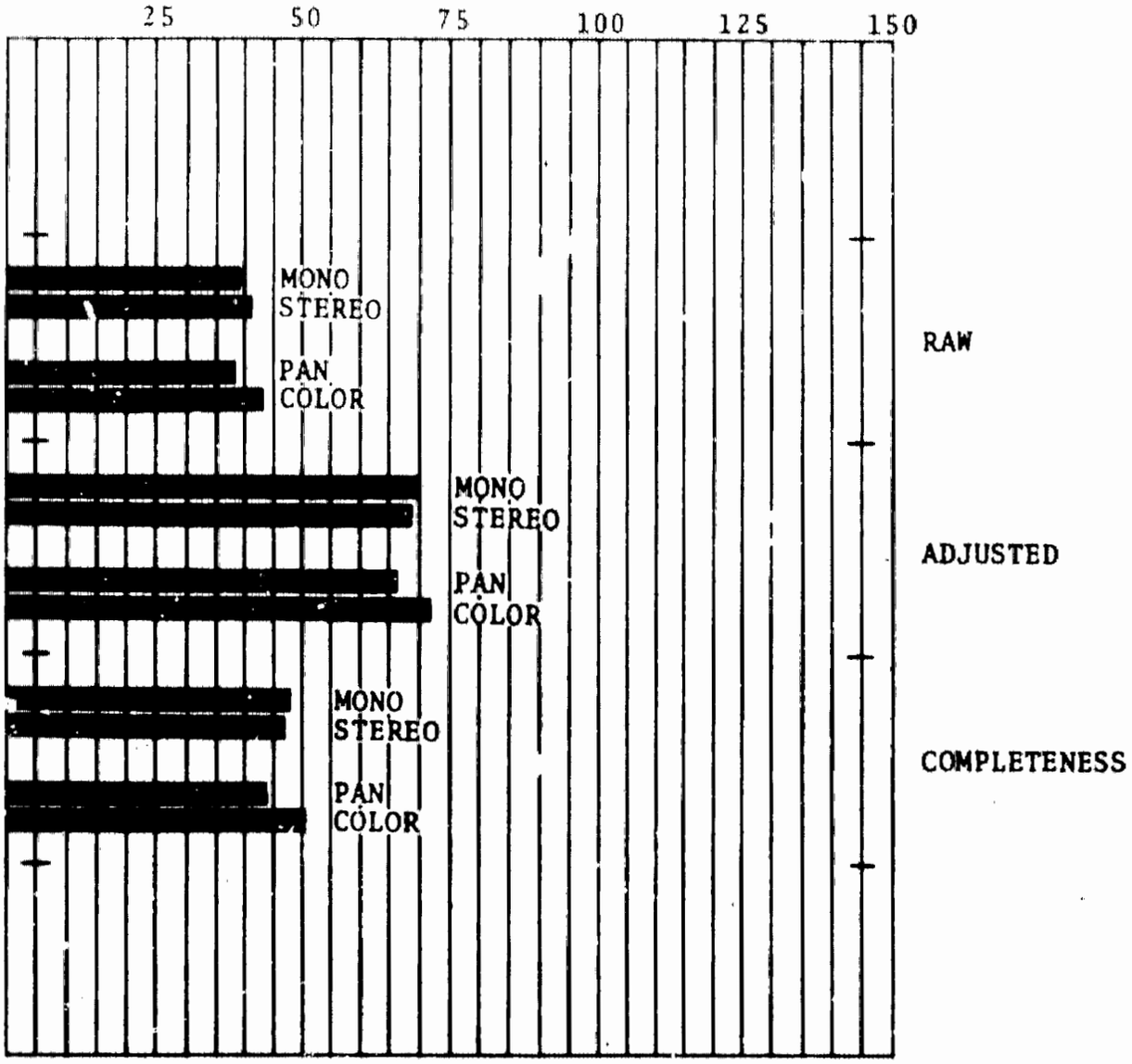


FIGURE 6

5.5 Problem 3. Search: High Target Density/Rural Background

This problem was parallel to the first search problem (5.3 above) in that it involved finding and counting many targets of an easily-identified type. Again the primary objective was to test the orderliness, completeness and speed of the search performed. However, the background in this case was rural, characterized by the more organic patterns of line, tone and texture typical of relatively undisturbed natural topography and ground cover.

5.5.1 Task 5

The assigned task was to detect and count all sampans imaged in forty-eight frames of 70mm vertical photography covering a canal village in Southeast Asia. The panchromatic and color imagery was flown concurrently at a scale of 1/2,500. Fifty-four sampans were imaged. Subjects were asked to report targets in groups of ten, a final count and confidence in its completeness. Twenty-five minutes were allowed for the search. Monitors also recorded elapsed time at each report of ten targets and at the final report. Because of the large photo scale and the simplicity of the target, it was assumed that the number of false targets reported would be insignificant.

5.5.2 Task 6

Subjects were asked to detect and count within 15 minutes all transmission line towers imaged in coverage of a rural

area near San Francisco. One hundred and nine targets were included in the test imagery. Both panchromatic and color imagery samples consisted of twelve frames of 70mm vertical photography collected concurrently at a scale of 1/40,000. Again, targets were reported in groups of ten, and the task was completed with a final count and a statement of confidence in its completeness. Elapsed time was recorded at each report. Because of the unique character of the target and the rural background of the imagery, it was assumed that only an insignificant number of false targets would be reported.

5.5.3 Findings

Both basic and confidence-weighted mean adjusted scores indicated a statistically significant difference in favor of color film analysis. The mean adjusted score for color analysis bettered that for pan analysis by approximately 25%. Basic mean scores for completeness showed a near-significant advantage for color analysis which became significant when weighted for confidence. Minor advantages for color analysis were also recorded in basic and confidence-weighted mean raw and speed scores. Mean scores for mono and stereo analysis showed very little difference.

5.5.4 Discussion

The advantage indicated for color analysis may be due to the fact that targets in this problem were imaged against natural background which was relatively homogeneous in comparison to the background in Problems 1 and 2. In this context, color

clues might be expected to be more distinguishing. It is interesting to note that the advantages for color film shown at the problem level were carried through both tasks, and were magnified in Task 6 where the background characteristics were most uniform. See Figures 7 and 8.

PROBLEM NO 3. SEARCH: HIGH TARGET DENSITY/RURAL BACKGROUND

BASIC MEAN SCORES

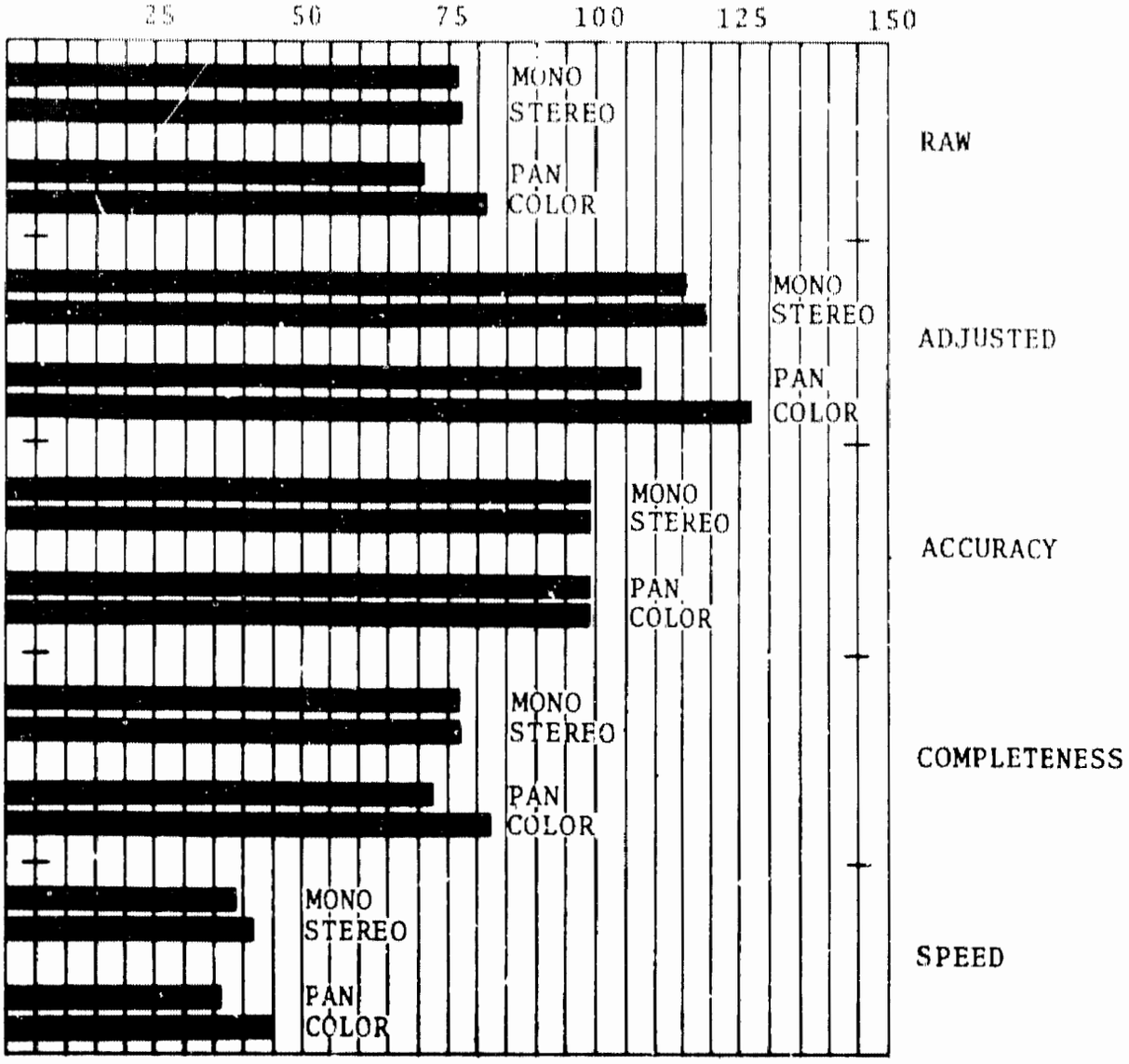


FIGURE 7

PROBLEM NO 3. SEARCH: HIGH TARGET DENSITY/RURAL BACKGROUND

CONFIDENCE-WEIGHTED MEAN SCORES

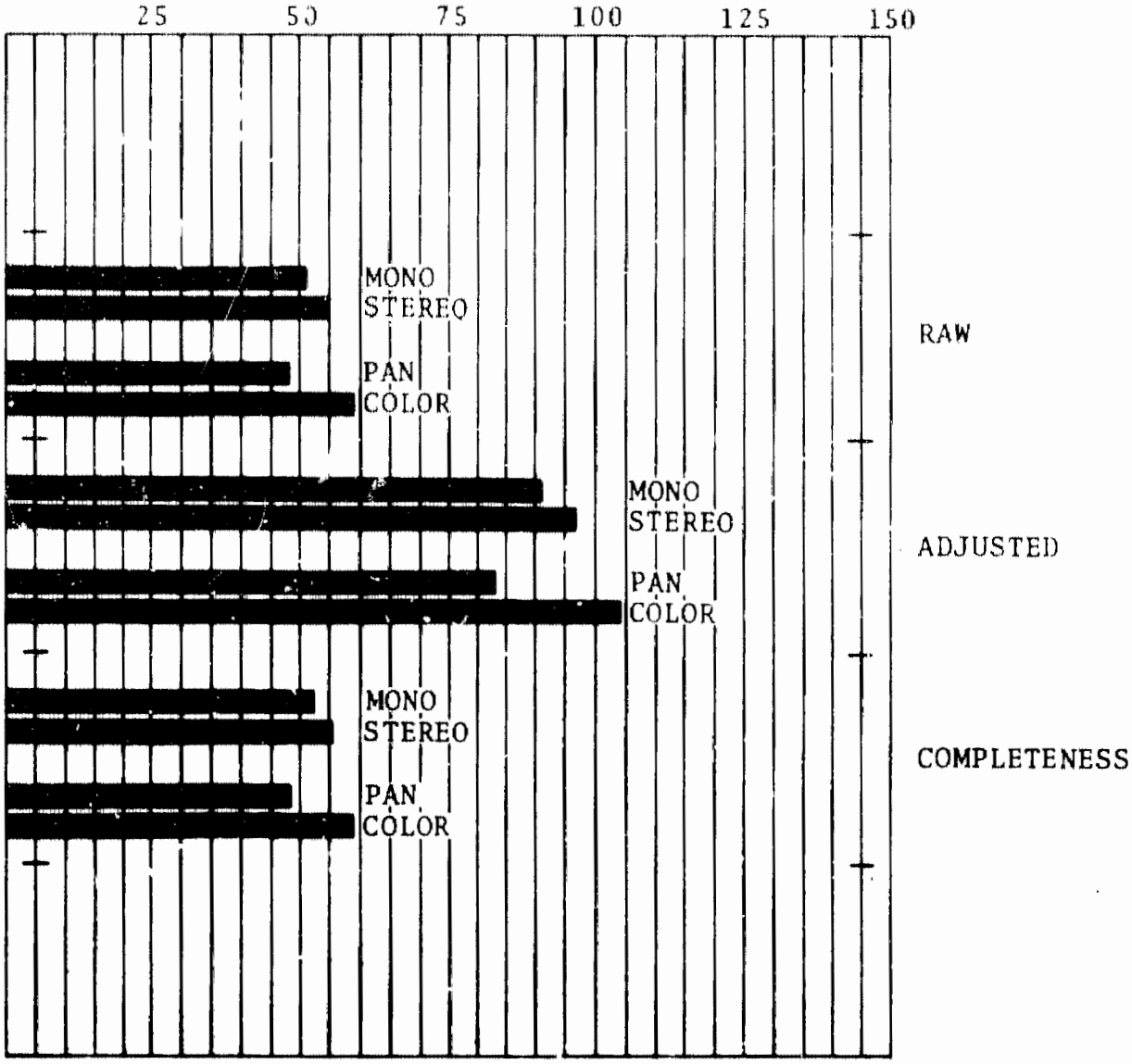


FIGURE 8

5.6 Problem 4. Search: Low Target Density/Rural Background

As in the second search problem (5.4 above), the subject was to find rare and/or isolated targets. In this case, however, the background was rural and primarily natural, rather than urban and cultural. Selected targets were easily identifiable and well-imaged, so that success depended primarily on thoroughness and speed, rather than analytical skill.

5.6.1 Task 7

Subjects were given ten minutes to detect and count all military vehicles shown in test imagery covering a lightly wooded maneuver area at Camp Drum, New York, during a late winter armored exercise. Panchromatic imagery consisted of four 9" vertical frames at a scale of 1/1,000 on which an area of interest (a plot of color photo coverage) was outlined. The color sample included three 5" frames at a scale of 1/10,000. Coverage was very nearly comparable in time, but not in line of flight, nor scale, as already noted. However, an approximate balance of target image density -- the relation of target image size to image field -- was maintained. Nine targets were imaged. Monitors recorded total counts and elapsed times, plus confidence levels. Reported targets were checked for accuracy of interpretation.

5.6.2 Task 8

Subjects were asked to detect and count all water buffalo imaged in coverage of a Southeast Asia village at a scale of 1/2500.

Ten minutes were allowed for the search. The test samples were strips of forty-eight frames of 70mm film collected concurrently. While this imagery was also used for the count of sampans in Task 5, spot checks of subjects indicated no significant carry-over from one task to the other. Monitors checked reports for "false alarms", then recorded total counts, elapsed time, and completeness confidence levels.

5.6.3 Findings

Considering the problem as a whole, no statistically significant differences in mean scores across test variables were found. Minor differences in favor of monocular interpretation and panchromatic imagery were shown in the basic raw and completeness mean scores and in favor of stereo interpretation and color imagery in mean speed scores. These contradictions nearly cancelled one another in the adjusted mean scores. Mean accuracy was uniformly high across all variables in keeping with the design of the problem (see Figure 9). Confidence-weighting of basic mean raw and completeness scores reinforced the minor differences slightly (see Figure 10).

5.6.4 Discussion

Examination of mean scores at the task level shows that a wide divergence between tasks was masked when problem level mean scores were compiled. The task mean scores agree with one another only in showing uniformly high accuracy across all variables and slight bias in speed scores in favor of stereo viewing

PROBLEM NO 4. SEARCH: LOW TARGET DENSITY/RURAL BACKGROUND

BASIC MEAN SCORES

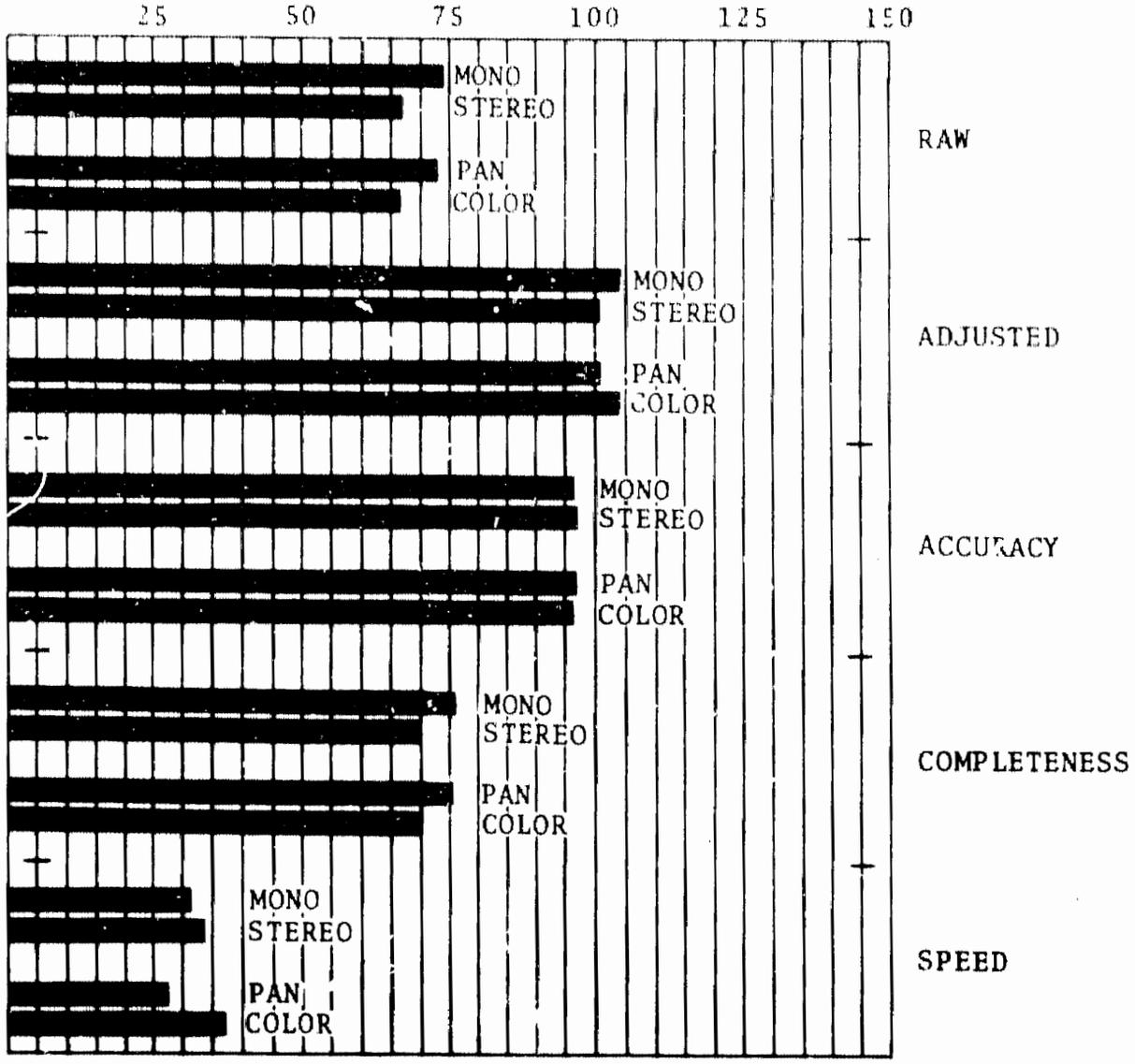


FIGURE 9

PROBLEM NO 4. SEARCH: LOW TARGET DENSITY/RURAL BACKGROUND

CONFIDENCE-WEIGHTED MEAN SCORES

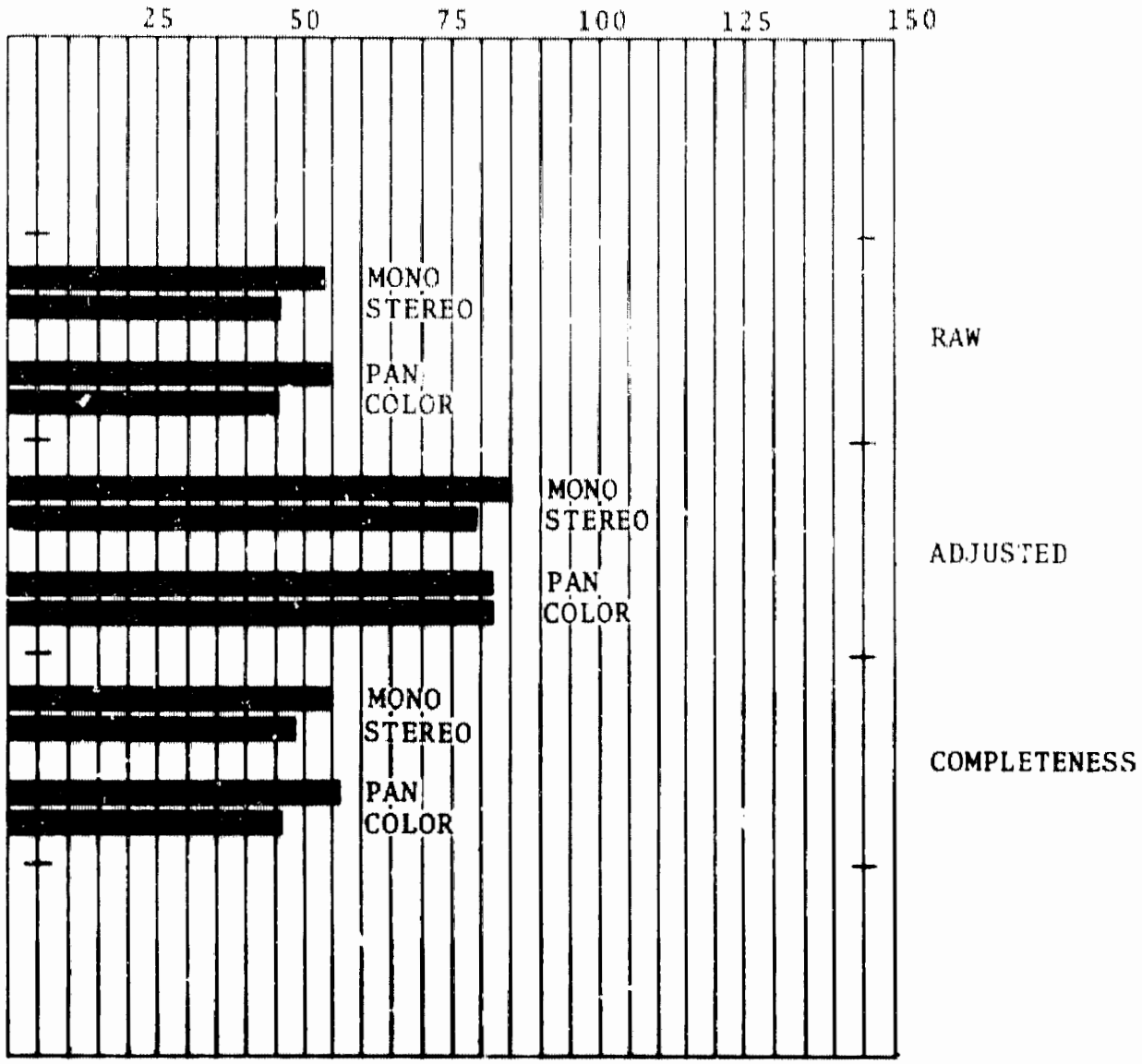


FIGURE 10

and color imagery. Otherwise Task 7 mean scores show a strong bias for monocular viewing and a stronger one for panchromatic film, while Task 8 mean scores show the opposite to a somewhat more moderate degree. Reconsideration of test materials in light of subject performance leads to the speculation that Task 8 was the more reliable of the two tasks and probably yielded more valid indications of the relative merits of the test variables, mainly because its imagery samples were collected concurrently. Conversely, test data would seem to indicate that in the selection of test imagery for Task 7 the attempt made to balance scale differences by maintaining an approximate ratio of target image size to overall imagery field did not succeed, and that the test was biased in favor of the larger scale panchromatic imagery. On this basis, it would seem that the problem results are of questionable value.

5.7 Problem 5. Analysis: Target Detail Discrimination

This problem was one of analyzing details of selected complex target images and determining or inferring specified items of target information. The target search which is normally part of operational interpretation was eliminated by annotating targets on the test imagery. In that desired items of target information were extracted on request, the analysis was closely controlled and focused almost exclusively on the interpretability of imagery detail. Information was requested in order of increasing difficulty, based on the fineness of detail to be analyzed, which approached and in some cases exceeded the apparent resolution limits of the test imagery. Selected targets were types with which the interpreters had some familiarity, and briefings designed to eliminate individual differences in target knowledge were given prior to each task.

5.7 1 Task 9

Subjects were asked to analyze imagery covering five bridges in the Annapolis area and to answer as many as possible of seven questions about each. The questions, asked in an ascending order of difficulty, concerned bridge use, construction and size. Up to thirty minutes were allowed for the task. Film samples were comparable strips of 9" vertical photography at a scale of 1/20,000. Twelve frames were included in the panchromatic sample and eleven in the color sample. The bridges under question were annotated on each sample. Monitors recorded each

response, the subject's confidence in its accuracy, and elapsed time at each response.

5.7.2 Task 10

Subjects were required to study and identify specified components of the Brooklyn Navy Yard imaged in 1/40,000 scale vertical photos. They were asked first to choose among several alternative identifications for each of twelve installations within the yard, and then to identify and count the various types of cranes in the yard. Keys were provided for both parts of the task and explanations of shipyard operations in the abstract were given on request. Twenty minutes, exclusive of briefing time, were allowed for the problem. Each film sample consisted of three 70mm frames. Samples were collected concurrently. Monitors recorded each identification along with response time and accuracy confidence.

5.7.3 Findings

At the problem level, both basic and confidence-weighted mean adjusted scores showed a significant difference in favor of color analysis. The difference in favor of color analysis was also shown significantly in basic speed scores and to a minor extent in all other scores. Monocular viewing was significantly more effective than stereo viewing in confidence-weighted mean adjusted scores, and showed a minor advantage in all other scores. No reversals took place when scores were weighted for confidence. See Figures 11 and 12.

PROBLEM NO 5. ANALYSIS: TARGET DETAIL DISCRIMINATION

BASIC MEAN SCORES

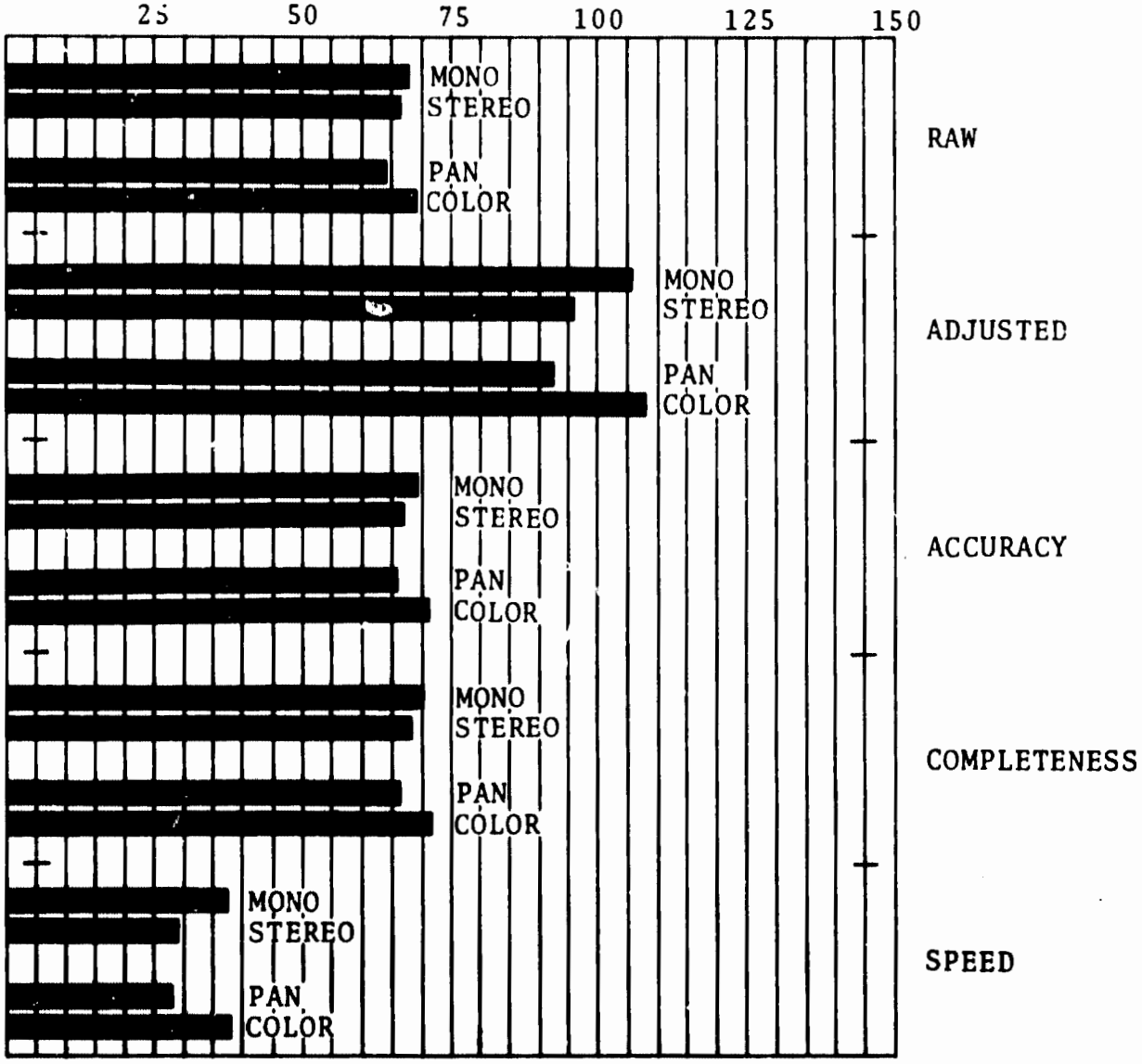


FIGURE 11

PROBLEM NO 5. ANALYSIS: TARGET DETAIL DISCRIMINATION

CONFIDENCE-WEIGHTED MEAN SCORES

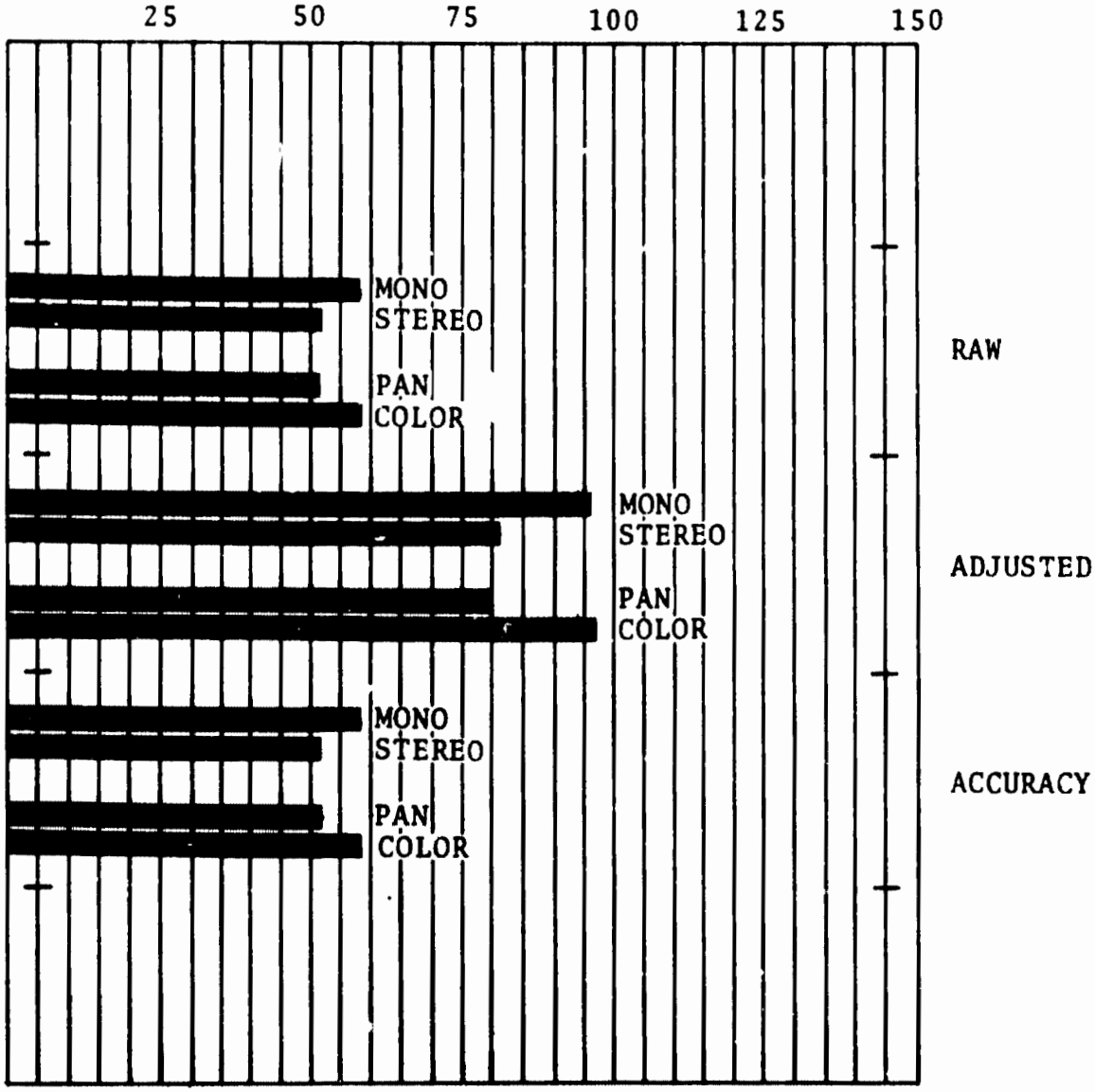


FIGURE 12

5.7.4 Discussion

The advantage of color film in overall performance (see mean adjusted scores) was due very largely to its speed advantage, though color film also showed a slightly better overall error rate (see mean raw scores). In that color film showed some degree of advantage over panchromatic film in all aspects of scoring of both tasks making up the problem, it would seem that the problem level results were reliable.

The results which showed significant overall superiority of monocular viewing over stereo viewing at the problem level may be somewhat less reliable, in that the task level basic scoring showed very mixed results in regard to the effects of viewing mode. At this level, monocular viewing showed a marked advantage over stereo viewing only in the speed and adjusted scores for Task 9 (detailed analysis of bridges), which presented no particular need for sensing depth or height.

Subjects seem to have been somewhat optomistic in stating confidence in their accuracy on this problem. While accuracy scores showed an error rate of approximately 30%, confidence-weighting discounted scores only about 20%. It is worth noting that this rate is a composite of a very high confidence in performance on Task 9 and a more accurate, but still high, confidence estimate on Task 10. The disparity between problems, which crossed all variables, is most probably due to the wide difference in imagery scales between the tasks.

On the other hand, the completeness scores in the 70% range indicate that subjects failed to respond in a significant number of situations. In Task 9, failure to respond was completely voluntary, in Task 10 it was largely due to failure to detect and identify all the cranes within the shipyard complex analyzed. In either case it indicates difficulty in completing the required work which would seem to discourage high confidence estimates.

5.8 Problem 6. Analysis: Single Target Identification

The core of this problem was differentiation, by close analysis, of targets of a specific category from the remainder of a broader category. The desired targets were distinguishable from the larger field by easily recognizable signature details. Imagery scales, however, were small in relation to the size of these crucial details and very close observation of the test imagery was required.

5.8.1 Task 11

Using the same Southeast Asia village film samples examined in Task 5 (5.5.1 above), the subject was asked to re-examine the sampans previously detected and determine how many were manned. Twenty minutes were allowed for the analysis. Samples were concurrent, each consisting of a strip of forty-eight 70mm frames at 1/2,500 scale. Subjects reported each group of ten found, a final count and their confidence in the accuracy of their interpretation. Fourteeen manned sampans were imaged.

5.8.2 Task 12

Subjects were asked to analyze the vessels detected in Bayonne Harbor in Task 2 (5.3.2 above) and count all those showing open holds. Twenty minutes were allowed to find the eight vessels imaged which showed this detail. The imagery samples were concurrent, each consisting of three 70mm frames at 1/165,000 scale. It was recognized that the scale was extremely small for extraction of the required information, and subjects were reminded

that they might decline to respond if they felt the imagery could not sustain the required analysis. Subjects were instructed to report targets in groups of ten, a final count and their confidence in the accuracy of their interpretation.

5.8.3 Findings

No significant differences were found in any aspect of this problem. Performance with monocular and stereo viewing were very similar in both basic and confidence-weighted scores, though very minor reversals took place between them. Except for speed scores, where color analysis showed a very slight advantage, panchromatic analysis showed a minor advantage in all scores, both basic and confidence-weighted. See Figures 13 and 14.

5.8.4 Discussion

Problem level results masked striking differences in all aspects of performance between Tasks 11 and 12. Task 11 mean scores showed approximate equality between the viewing modes and a modest advantage for color film in speed and overall performance. Task 12 mean scores, on the other hand, showed a modest advantage for stereo viewing and a pronounced advantage for panchromatic film. In addition, Task 11 mean scores were, overall, much higher than Task 12 mean scores. For example, while the average of mean raw scores for Task 11 was about 90, the average of Task 12 mean raw scores was about 25. This difference was accentuated by confidence-weighting.

PROBLEM NO 6. ANALYSIS: SINGLE TARGET IDENTIFICATION

BASIC MEAN SCORES

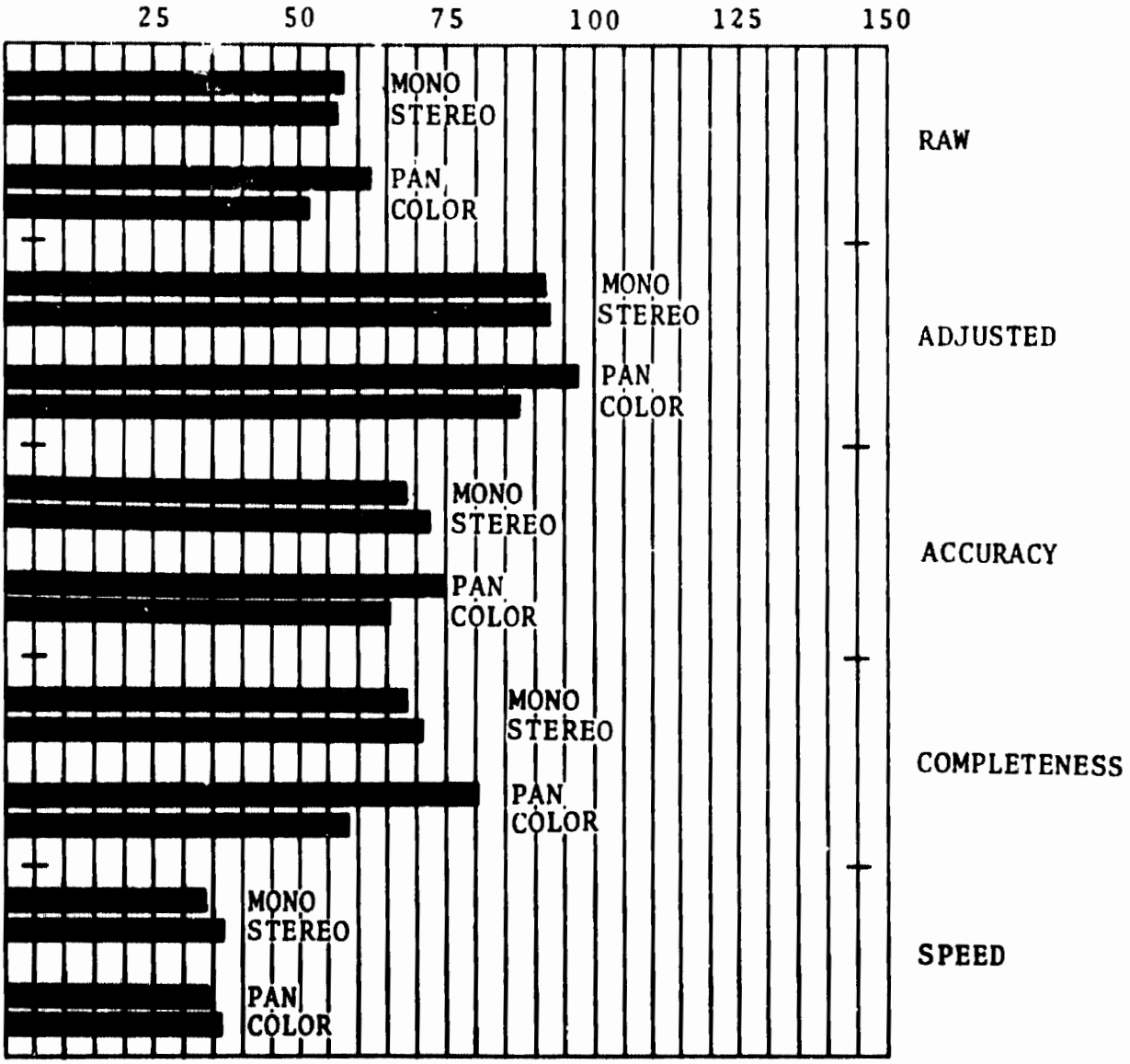


FIGURE 13

PROBLEM NO 6. ANALYSIS: SINGLE TARGET IDENTIFICATION

CONFIDENCE-WEIGHTED MEAN SCORES

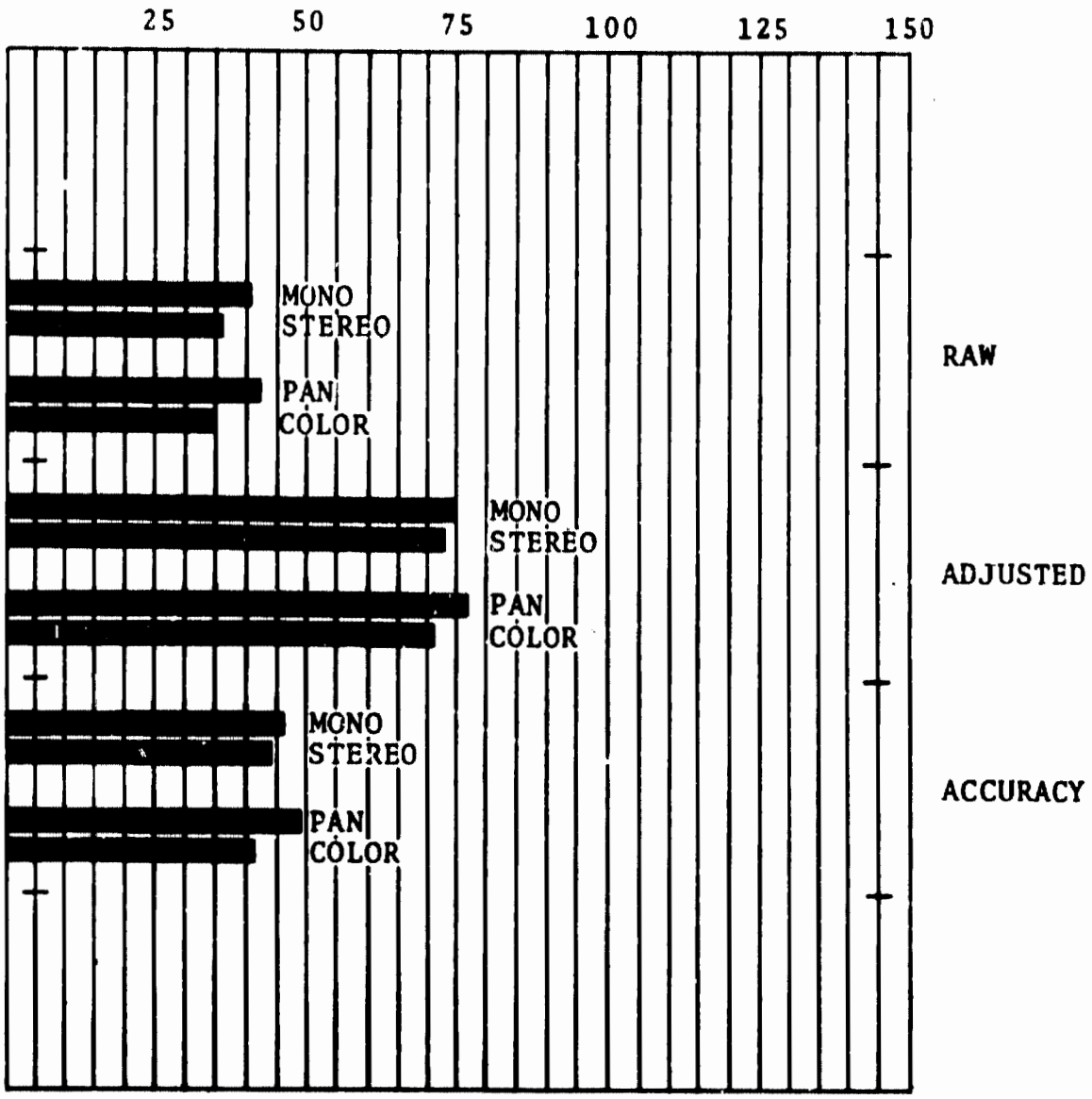


FIGURE 14

This disparity is apparently traceable to scale differences between the sets of imagery -- 1/2,500 in Task 11 and 1/165,000 in Task 12 -- and may be indicative of a basic consideration in comparing panchromatic and color films in aerial reconnaissance. When scale is large in relation to target size, as in Task 11 and Task 5 where the same image is used, there is a tendency for color imagery to allow faster interpretation. However, when imagery scale is small enough in relation to target size to put the required information near the resolution limits of the imagery the situation is reversed, largely because any benefits that may accrue through the presence of color clues tend to be more than offset by its lack of resolving power when compared to fine-grained panchromatic film. In support of this contention, it should be noted that, while in Task 11 all subjects responded under all conditions, in Task 12 the "no response" rate rose sharply, but more so for color than for pan imagery. While the "no response" rate for color imagery was 76%, it was only 66% for panchromatic imagery.

5.9 Problem 7. Analysis: Multiple Target Identification

This problem involved specific identification of selected targets within the same general category. Annotated targets were identified by analysis and categorization of details common to all. No target search was required. Details which served as a basis for identification were imaged, at best, at small scales in relation to size, and in some cases were beyond the apparent resolution limits of the test imagery. Details were analyzed in order of increasing difficulty by groups covering all targets before decisions on individual target identities were called for. Keys leading from detail analysis to identification were provided for this last step. Success depended upon interpretability of target image detail, and analysts were encouraged to decline to continue the analysis if they felt the image quality would not allow it.

5.9.1 Task 13

Subjects were asked to identify the class of each of eight submarines by determining four key details in regard to each as imaged in 1/40,000 scale photos. The imagery samples were concurrently collected and each consisted of four 70mm frames. The details to be determined were hull type, conning tower position, hatch openings, and length. A key identifying submarine classes by these details was provided to aid in final classification. Monitors recorded responses,

confidence in the accuracy of each and elapsed time for each response. Time allowed for the analysis was thirty minutes.

5.9.2 Task 14

Using 1/40,000 scale photos of LaGuardia Airport, New York City, subjects were asked to identify ten aircraft on the basis of wing type, number of engines, engine type, and employment on the field. Each of the foregoing items was determined for all aircraft before final identification was made with the aid of an appropriate key and mensuration. Thirty minutes were allowed. Imagery samples were concurrently collected and each included five 70mm frames. Monitors recorded all responses, an estimate of confidence in the accuracy of each and elapsed time at each response.

5.9.3 Findings

At the problem level, scores for all cases of the test factors were very similar, whether basic or confidence-weighted. No statistically significant differences occurred, nor did confidence weighting reverse any of the minor differences shown. In every aspect of the problem, comparison of basic and confidence-weighted scores indicated that mean confidence was found to be high in relation to performance. See Figures 15 and 16.

5.9.4 Discussion

Once again, results at the problem level damped out some minor differences between results at the task level. In this case, while Task 13 (submarine analysis) results showed a

PROBLEM NO 7. ANALYSIS: MULTIPLE TARGET IDENTIFICATION

BASIC MEAN SCORES

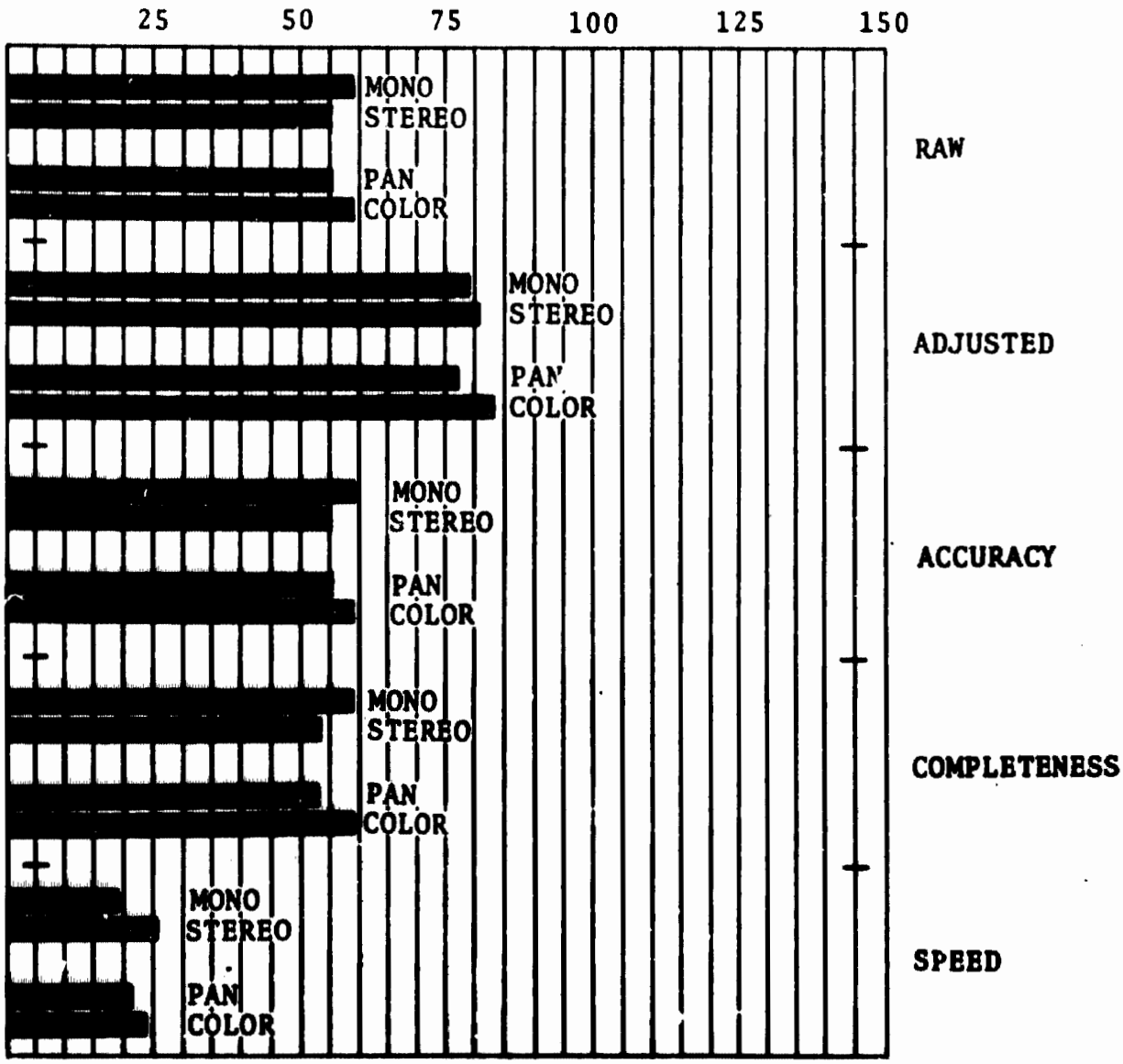


FIGURE 15

PROBLEM NO 7. ANALYSIS: MULTIPLE TARGET IDENTIFICATION

CONFIDENCE-WEIGHTED MEAN SCORES

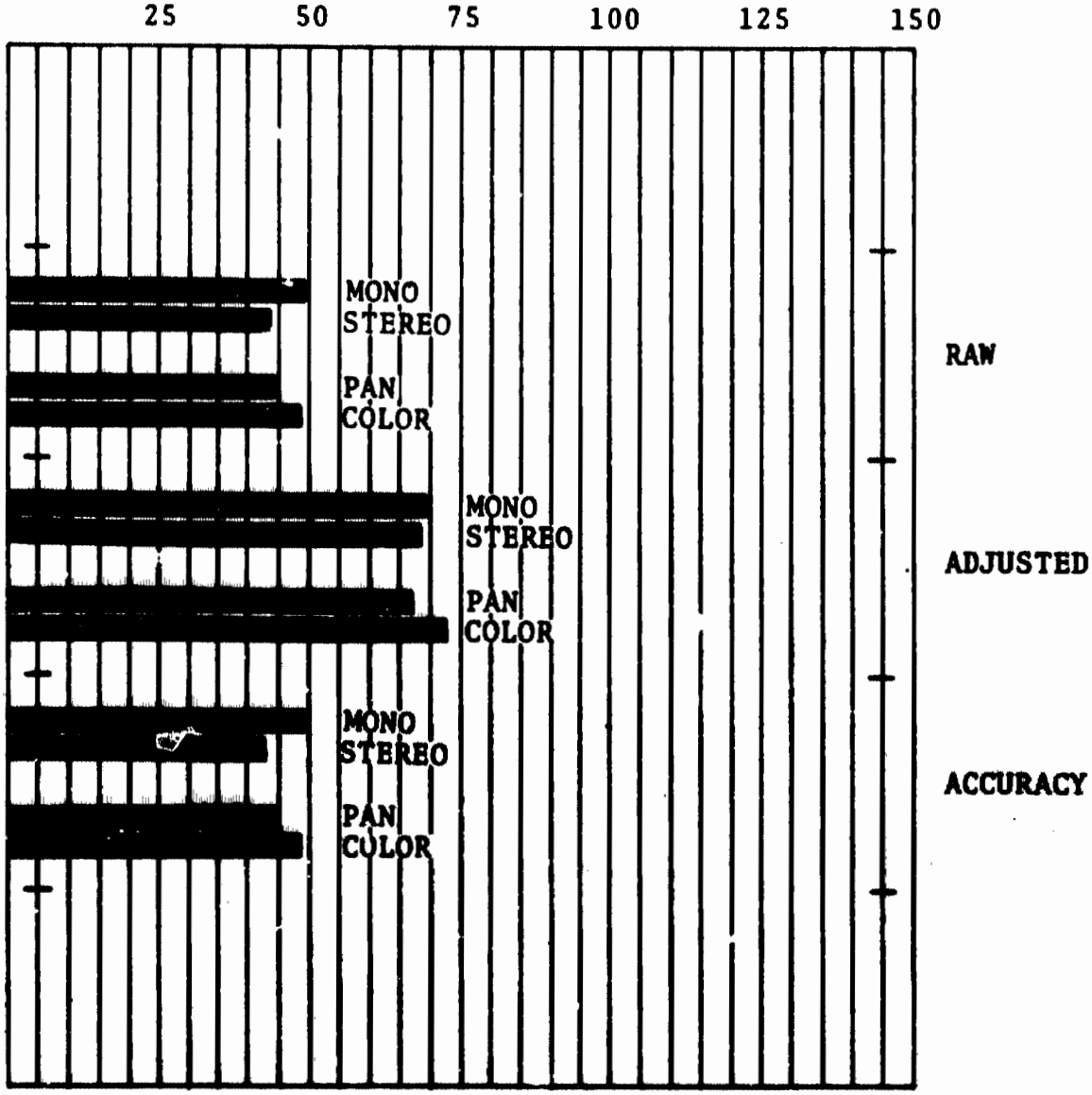


FIGURE 16

small, but consistant, advantage for panchromatic film; Task 14 (aircraft analysis) mean scores showed a minor advantage for color film in all aspects of scoring. This reversal was probably due to differences between the particular task situations. In Task 13 there was very little hue difference between targets and background, so color imagery offered no unique advantages, and its lower resolution made it somewhat inferior to panchromatic imagery in the particular case. The reverse was true in Task 14, where some hue differences separate targets from background and the color film thus offered an additional clue not included in the pan imagery. The incidence of failures to respond tends to reinforce this analysis: in Task 13 instances of failure to respond numbered 37 for panchromatic film, 66 for color film; while in Task 14 instances numbered 80 for panchromatic, only 25 for color film.

As in Problem 5, however, these substantial "no response" rates, and the reversal between tasks, were recorded alongside uniform confidence in accuracy, which was somewhat high in comparison to performance.

5.10 Problem 8. Delineation

This was a problem of categorizing specified superficial features within a sizeable rural tract according to a given system and determining boundaries between categories. The features analyzed were generally familiar to the test subjects, and the systems of categorization were self-explanatory. Thus, the problem focused on the effectiveness of each film type in providing clues for boundary delineation.

5.10.1 Task 15

Subjects were asked to study 1/40,000 imagery of a tract of rural land near Bennettsville, South Carolina and determine the type of ground cover predominating within designated squares of an overlaying grid. Six categories were considered, and fifteen minutes were allowed for the analysis. No responses were recorded until the subject indicated he had completed a general analysis. Samples were congruent and consisted of three 9" vertical frames each. Monitors recorded eighteen responses, accuracy confidence for each and total elapsed time for the problem.

5.10.2 Task 16

Subjects were asked to map ground cover types within another rural tract near Bennettsville, South Carolina in six categories. Thirty minutes were allowed for completion. Mapping accuracy was then measured by applying a grid to the map and reading out the predominant ground cover type shown in twelve

selected squares. Samples were congruent, each consisting of three 9" vertical frames at 1/40,000 scale. Monitors recorded mapping time, twelve responses and accuracy confidence for each.

5.10.3 Findings

Mean scores of all types were very similar to one another at the problem level, except for the case of basic adjusted score for film type, where color analysis showed a minor advantage. No statistically significant differences were recorded. Confidence-weighting caused no important reversals between test factors. See Figures 17 and 18.

5.10.4 Discussion

Minor reversals in various aspects of scoring took place between Tasks 15 and 16, but results were similar enough to indicate that both tasks functioned as designed. The lack of a clear advantage for one film type or the other may be attributable to the fact that no strong hue differences normally exist between the ground cover categories which were differentiated, so that color clues were not crucial. At the same time, the details of form being analyzed were not so small in scale as to make the better resolution of pan film decisive.

Throughout the problem, confidence in accuracy was uniformly higher than was justified by actual performance. There were no instances of failure to respond.

PROBLEM NO 8. ANALYSIS/DELINEATION: MAPPING

BASIC MEAN SCORES

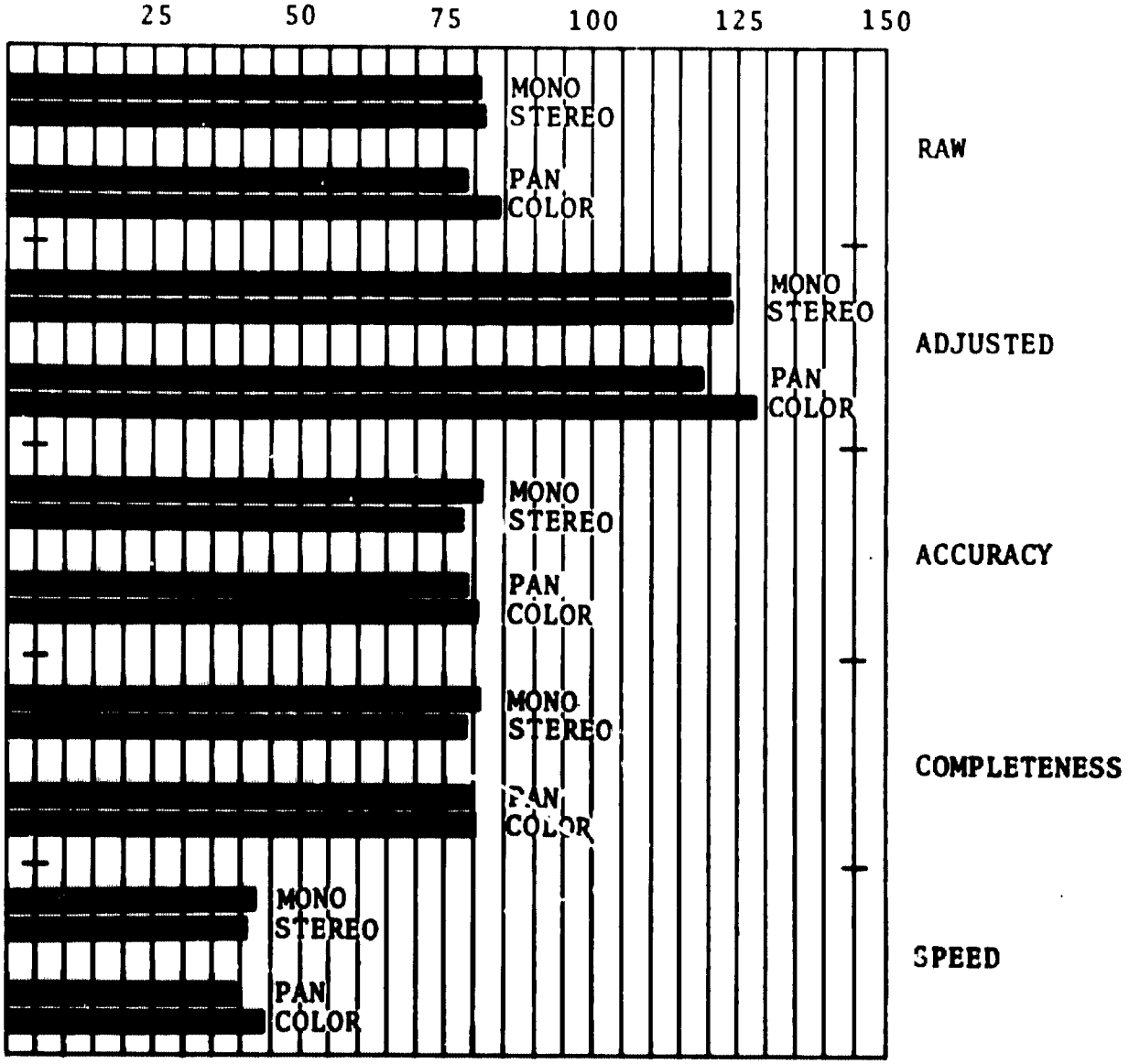


FIGURE 17

PROBLEM NO 8. ANALYSIS/DELINEATION: MAPPING

CONFIDENCE-WEIGHTED MEAN SCORES

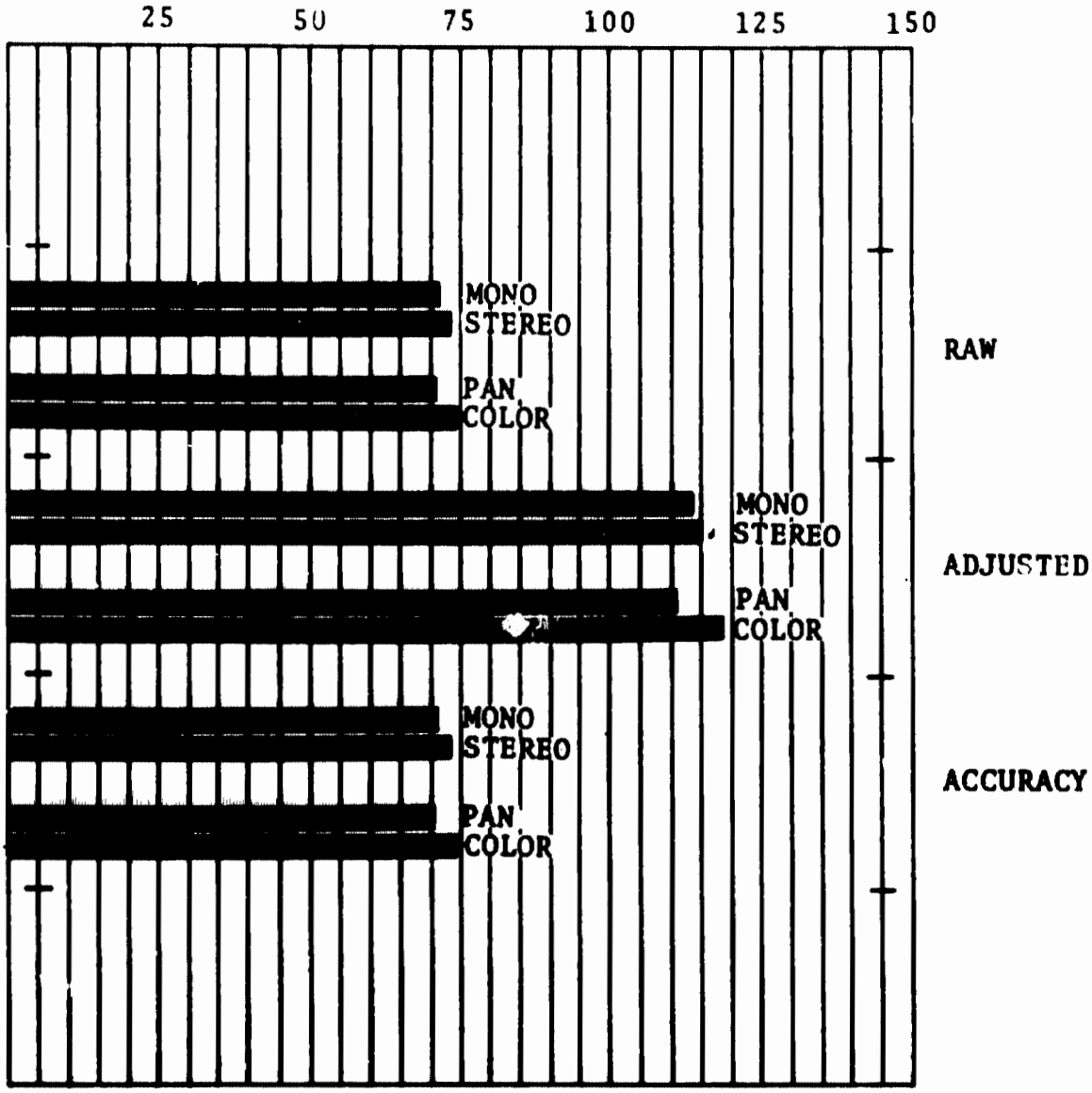


FIGURE 18

6. CONCLUSIONS AND RECOMMENDATIONS

It appears that the test was valid and produced reliable results. Recognizing the limitations of the test, extrapolations of the results to real reconnaissance situations are, nevertheless, possible. The testing program yielded no completely unexpected results. In particular, the test revealed no qualities of color film in reconnaissance applications which were not previously speculated upon.

Neither color nor panchromatic film displayed a commanding advantage in aerial reconnaissance, either generally or in relation to specific tasks. However, such modest advantages as were found were all in favor of color film. These advantages were not of such a magnitude as to indicate an immediate shift in reconnaissance techniques. Rather, they indicate that color photography must be seriously considered by reconnaissance planners. That is, in choosing between films possible gains from color film use must be weighed against additional costs in light of the importance of particular missions.

Specifically, the test indicated the following in regard to the usefulness of color film in aerial reconnaissance:

(1) Use of color film instead of panchromatic may speed interpretation by approximately 15%.

(2) Use of color film may result in slightly lower error (missed target) rates in searching

operations, the degree of reduction being most directly related to the difference in hue between target and background.

(3) Use of color film has little effect on the accuracy of analytical interpretation, except when image scale is small or marginal in relation to target size. In this case, accuracy of color film interpretation tends to be lowered in relation to panchromatic film analysis presumably because the coarser grain structure and lower resolution of the color film emulsion lead to higher misinterpretation rates and more refusals to respond.

(4) In situations where analysis is attempted, however, interpreter confidence is not significantly affected by the type of film presented for analysis.

On the basis of this test it is recommended that color film be used in reconnaissance operations: where color clues are expected to be significant in determining desired information, where coverage requirements are limited enough to allow collection at moderate-to-large scales in relation to target size without unduly lengthening the mission, and where analysis time savings in the range of 15% are deemed significant.

In further exploitation of the results of this program the following actions are also recommended:

(1) Investigation of the speed-of-analysis advantage recorded for color films and ways and means of increasing it.

(2) Investigation of the effectiveness of color films as compared to pan films in searches for concealed or camouflaged tactical military targets.

(3) Inclusion in photo interpretation keys of information on target color as an aid to reconnaissance planning.

(4) Investigation of interactions between film type and viewing mode in photo interpretation.

(5) Investigation of the usefulness of induced color techniques in reconnaissance imagery interpretation.

APPENDIX A

TEST ADMINISTRATION MATERIALS

COLOR RECONNAISSANCE TESTING

ADMINISTRATOR'S INSTRUCTIONS AND SCRIPT

Please follow these instructions as closely as possible in presenting the Color Reconnaissance Test to each subject assigned to you. By doing so, you will insure that the data we collect will be valid and the test we have worked so long to prepare will be successful in advancing the state-of-the-art of aerial reconnaissance.

Before each subject reports to take the test, check to be sure that you have everything listed on the check list; test imagery, equipment, graphics and forms.

When the subject is ready to begin ask him first to complete the Subject Biography. This should take 3-5 minutes. Check the form for completeness and legibility before accepting it.

Read the following general instructions to the subject:

THE TEST YOU ARE ABOUT TO BEGIN IS MADE UP OF 17 PROBLEMS DESIGNED TO TEST THE INTERPRETABILITY OF VARIOUS TYPES OF PHOTOGRAPHY UNDER A VARIETY OF CONDITIONS. WHILE YOU ARE NOT BEING TESTED PERSONALLY, WE ASK THAT YOU DO YOUR BEST SO THAT OUR DATA WILL BE ACCURATE. THE TASKS INVOLVED ARE FINDING, COUNTING, ANALYZING, IDENTIFYING AND DELINEATING VARIOUS TACTICAL TARGETS OR EQUIVALENTS ON VERTICAL AERIAL PHOTOS BY EITHER MONOCULAR OR

STEREOSCOPIC STUDY. YOU WILL BE GIVEN APPROPRIATE INTERPRETATION TOOLS, KEYS, AND OTHER GRAPHICS FOR EACH PROBLEM. PERFORMANCE WILL BE MEASURED FOR ACCURACY, COMPLETENESS AND SPEED. TO SAVE YOU TIME AND TO INSURE ACCURATE RECORDING, SOLUTIONS TO EACH PROBLEM WILL BE RECORDED BY THE TEST MONITOR. HE WILL ALSO STAND BY THROUGHOUT THE TEST TO ANSWER QUESTIONS THAT MAY ARISE, KEEP TRACK OF TIME AND PRESENT THE PROBLEMS IN SEQUENCE. PLEASE DO NOT DISCUSS THIS TEST WITH OTHERS UNTIL WE HAVE COMPLETED ALL TESTING. FOR BEST RESULTS:

1. UNDERSTAND EACH PROBLEM BEFORE YOU START WORK ON IT.

2. BE SURE THE TEST IMAGERY IS PROPERLY ORIENTED ON YOUR LIGHT TABLE AND COVERED WITH AN ACETATE OVERLAY.

3. MAKE FULL USE OF THE EQUIPMENT AND AIDS SUPPLIED, AND MAKE ANY NOTES OR OVERLAYS WHICH YOU FEEL WILL BE HELPFUL TO YOU.

4. REPORT YOUR ANSWERS TO THE MONITOR IN THE MANNER REQUESTED AS QUICKLY AS POSSIBLE WITHOUT SACRIFICING COMPLETENESS OR ACCURACY.

5. DON'T GUESS -- OUR SCORING SYSTEM PENALIZES GUESSING. IN SOME CASES INFORMATION IS ASKED WHICH THE IMAGERY CANNOT SUPPLY; WHEN YOU FEEL YOU HAVE REACHED SUCH A CASE, SAY SO.

6. ESTIMATE YOUR CONFIDENCE IN EACH ANSWER AS ACCURATELY AS POSSIBLE.

DO YOU HAVE ANY QUESTIONS BEFORE WE BEGIN?

Answer any questions as briefly as possible.

When all questions have been disposed of, give the subject the pre-test problem imagery. Orient the imagery properly on the light table, see that it is covered by an overlay, and read the following instructions:

THIS IS A PROBLEM FOR MONOCULAR INTERPRETATION. YOU HAVE UP TO 5 MINUTES TO EXAMINE THE IMAGERY. THEN 5 QUESTIONS WILL BE ASKED. RESPOND AND INDICATE A CONFIDENCE LEVEL FOR EACH ANSWER AS QUICKLY AS POSSIBLE.

Record starting time on the subject's score sheet. Let him know when 3, 4, and 5 minutes have passed and then ask the questions on the problem sheet. As questions are answered record them on the subject's response record along with the time of each answer and the confidence level indicated by each subject. As soon as the subject has finished, move on to the test proper. Consult the subject's problem schedule for the order in which the problems are to be worked, what kind of imagery the subject should see, and how it should be studied.

For each problem:

1. Give the subject the imagery and orient it properly.

Make sure protective overlays are in place.

2. Indicate the mode of study to be used - mono or stereo.

3. Follow any special instructions given below for the problem.

4. Answer any questions briefly.

5. Note the time of starting, the subject's responses, the time of each response to the nearest 30 seconds, and the subject's confidence level in the proper places on the response record.

6. Collect all film and collateral data on each problem as it is completed and replace it carefully in your file for re-use.

7. If grease poncil notes have been made on the protective overlays, assure that the subject cleans the shield between problems.

Task 1. After giving the subject the film and the appropriate instructions for mono or stereo study read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. WHEN THE STARTING SIGNAL IS GIVEN, COUNT ALL HARD-SURFACED, MARKED, MULTIPLE VEHICLE PARKING LOTS WITHIN THE OUTLINED AREA OF

THESE PHOTOS, THAT IS, THE LARGER LAND AREA ON ONE SIDE OF THE RIVER ONLY, INDICATE EACH TEN AS YOU COUNT THEM, AND WITH YOUR FINAL TOTAL, RECORD ALSO YOUR LEVEL OF CONFIDENCE IN YOUR SOLUTION TO THE WHOLE PROBLEM. BE CAREFUL TO COUNT EACH LOT ONLY ONCE, AND EXCLUDE DRIVEWAYS TYPICAL OF ONE FAMILY HOUSES. YOU HAVE UP TO 20 MINUTES TO COMPLETE THIS PROBLEM, BUT WORK AS QUICKLY AS POSSIBLE. ANY QUESTIONS?

Answer questions as appropriate, point out a sample target not within the test area, check starting time and signal start. Announce time remaining at 5 minute intervals.

Task 2. In giving the subject the test film, be sure to indicate clearly that only the area covered by the center frame is to be studied. Then read the following instructions:

THE PROBLEM HERE IS TO DETERMINE THE NUMBER OF SELF-PROPELLED SHIPS SHOWN IN THE CENTRAL FRAME. EXCLUDE ANY BARGES, SMALL CRAFT UP TO THE SIZE OF TUGS AND BOATS FROM THE COUNT, BUT INCLUDE ALL MAJOR VESSELS REGARDLESS OF STATUS OR STATE OF MAINTENANCE. INDICATE GROUPS OF TEN AS YOU COUNT THEM, AND RECORD AN OVERALL LEVEL OF CONFIDENCE WITH YOUR TOTAL COUNT. ANY QUESTIONS? YOU HAVE UP TO 10 MINUTES FOR THIS PROBLEM.

Answer any questions as appropriate, check time and signal start. Announce time after five minutes.

Task 3. Give the subject the problem film and orient it properly. Present the target key sheet and read the following instructions:

> THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. SEARCH THE TEST FILM FOR THE TARGET TYPES LISTED ON THE KEY AND REPORT INDIVIDUAL TARGETS AS SOON AS YOU FIND THEM. IT IS RECOMMENDED THAT YOU SEARCH FOR TARGET TYPES ONE AT A TIME. INDICATE A CONFIDENCE LEVEL FOR THE COMPLETENESS OF YOUR FINAL COUNT OF EACH TARGET TYPE. BEFORE STARTING, CHECK THE LIST AND MAKE SURE YOU UNDERSTAND EACH TARGET TYPE LISTED. YOU HAVE UP TO 40 MINUTES FOR THIS TASK, BUT COMPLETE YOUR SEARCH AS QUICKLY AS POSSIBLE WITH ACCURACY. ANY QUESTIONS?

Answer questions, assure that the problem is understood, check time and signal starting time. Announce time after 20 minutes in 5 minute intervals.

When the subject signals that he has finished, consult with him on the location of the reported targets. Check against the target plot and record actual targets and false alarms. Remember that zero is a correct response in some cases.

Task 4. Present the test imagery in proper orientation, identify the frames to be studied, and read the following instructions:

> THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. SEARCH THE FRAMES INDICATED AND COUNT ALL ROAD, STREET OR HIGHWAY

CONSTRUCTION SITES. SITES MAY BE TYPIFIED BY EVIDENCE OF DIGGING, PRESENCE OF CONSTRUCTION EQUIPMENT OR MATERIALS, BY PARTIAL STRUCTURES, OR BY ANY COMBINATION OF THESE ELEMENTS. INCLUDE IN YOUR COUNT ALL SITES WHETHER OR NOT WORK IS ACTUALLY GOING ON IN THE PHOTOS AND NOTE LOCATIONS ROUGHLY ON THE PROTECTIVE OVERLAY. YOU WILL HAVE UP TO 20 MINUTES TO MAKE YOUR SEARCH. ANY QUESTIONS?

Answer questions, then signal starting time. Announce time at 10 and 15 minutes. When the subject signals that he is finished, check locations of reported sites for accuracy, and adjust score for any instances of targets lumped together, etc.

Task 5. Mount the test film on the light table and assure that a protective overlay is available. Read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. THIS FILM COVERS A VILLAGE SITE IN SOUTHEAST ASIA. YOUR PROBLEM IS TO COUNT ALL THE SAMPANS IMAGED ON THE 48 FRAMES YOU HAVE BEEN GIVEN. COUNT SAMPANS BOTH IN AND OUT OF THE WATER, WHETHER SERVICEABLE OR NOT, BUT BE CAREFUL TO COUNT EACH VESSEL ONLY ONCE. REPORT EACH 10 SAMPANS AS YOU FIND THEM AND A FINAL TOTAL. YOU HAVE UP TO 25 MINUTES TO COMPLETE THE COUNT BUT YOU SHOULD WORK AS QUICKLY AS POSSIBLE. STATE AN OVER-ALL CONFIDENCE LEVEL IN YOUR INTERPRETATION WHEN YOU FINISH. ANY QUESTIONS?

Answer questions, point out one easy-to-find sampan and signal starting time. Announce time at 15 and 20 minutes.

Task 6. Mount the test film on the light table and assure that a clean protective overlay is available. Read the following instructions:

> THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. THIS FILM COVERS A SEMI-RURAL AREA IN THE UNITED STATES. THE PROBLEM IS TO COUNT THE TRANSMISSION LINE TOWERS IMAGED IN THE STRIP OF 12 FRAMES WHICH YOU HAVE BEEN GIVEN. BE CAREFUL TO COUNT EACH TOWER ONLY ONCE. REPORT EACH TEN TOWERS COUNTED, YOUR TOTAL COUNT, AND YOUR LEVEL OF CONFIDENCE IN THE OVERALL ACCURACY OF THE COUNT. YOU WILL HAVE UP TO 15 MINUTES TO COMPLETE THE SEARCH. ANY QUESTIONS?

Answer questions briefly; then signal the starting time. Announce time at 5 and 10 minutes.

Task 7. Distribute the test film, orient it properly, and make sure that a clean protective overlay is in place. Then read the following instructions:

> THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOU ARE TO FIND AND COUNT THE MILITARY VEHICLES, IF ANY, WHICH APPEAR ON THE FRAMES (PAN PHOTOS)/WITHIN THE OUTLINES (COLOR PHOTOS). COUNT EACH VEHICLE ONLY ONCE. REPORT VEHICLES IN GROUPS OF TEN, BUT ALSO REPORT YOUR TOTAL

COUNT AND AN OVERALL LEVEL OF CONFIDENCE IN ITS ACCURACY. YOU WILL HAVE UP TO 10 MINUTES TO COMPLETE THIS PROBLEM. ANY QUESTIONS?

Answer questions, then signal starting time. When the subject indicates completion, check his detections against the target plot for accuracy and record false alarms if necessary.

Task 8. Mount the test film, properly oriented, on the light table and cover with a clean overlay. Read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOU ARE TO FIND AND COUNT THE WATER BUFFALO, IF ANY, WHICH ARE IMAGED IN THE VILLAGE COVERED BY THE 20 FRAMES YOU WILL EXAMINE. WATER BUFFALO ARE VARIOUS SHADES OF LIGHT GREY IN COLOR, AND ABOUT THE SIZE AND CONFORMATION OF A LARGE COW. THEY MIGHT BE FOUND ANYWHERE IN THE AREA IMAGED. COUNT EACH ANIMAL ONLY ONCE. REPORT GROUPS OF TEN, THE TOTAL COUNT AND YOUR CONFIDENCE IN ITS ACCURACY. YOU WILL HAVE UP TO 10 MINUTES TO COMPLETE YOUR SEARCH. ANY QUESTIONS?

Answer questions, then signal starting time. When the subject signals completion, check the location of his targets, and record false alarms, if necessary.

Task 9. Mount the test photos in proper orientation. Check to see that a clean protective overlay is in place. Give the subject

the question sheet and bridge key, and read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOUR TASK IS TO STUDY THE NUMBERED BRIDGES IN ORDER AND ANSWER AS MANY AS POSSIBLE OF THE 7 QUESTIONS WHICH WILL BE ASKED ABOUT EACH ONE. GIVE ONLY THOSE ANSWERS WHICH YOU CAN VERIFY FROM THE IMAGERY AND INDICATE YOUR CONFIDENCE IN EACH ONE. DON'T GUESS. YOU WILL HAVE UP TO 30 MINUTES. ANY QUESTIONS?

Answer questions briefly, check time and signal start. From your question sheet ask each question in order, stating any alternative answers give . Make sure that the subject studies the proper bridges. Clarify questions as necessary, but avoid any discussions of interpretation. Be sure to record a confidence level for each answer given.

Task 10. Mount the test photos in proper orientation and cover with an overlay. Give the subject a target diagram and key. Read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOUR TASK IS TO STUDY EACH NUMBERED SEGMENT OF THE TARGET SHOWN IN THE DIAGRAM. CONSULT THE KEY, AND ANSWER THE QUESTIONS WHICH WILL BE ASKED. EACH SEGMENT WILL BE DEALT WITH IN ORDER AND YOU WILL HAVE UP TO 20 MINUTES FOR THE PROBLEM. THE IMAGERY SHOULD BACK UP YOUR

ANSWERS: IN OTHER WORDS, DON'T GUESS. FOR EACH ANSWER, STATE YOUR LEVEL OF CONFIDENCE. ANY QUESTIONS?

Answer questions briefly, check time and start. Be sure that the subject correctly isolates each area to be studied, then, consulting your answer sheet, ask each question in order, including alternative answers where a choice is to be made. Be sure to record confidence levels for each answer.

Task 11. This problem will follow Task 5 and uses the same imagery. Read the following instructions:

THE NEXT PROBLEM IS MONOCULAR/STEREOSCOPIC. NOW THAT YOU HAVE COUNTED ALL SAMPANS, COUNT THE NUMBER WHICH ARE MOORED, THAT IS, HAVE PEOPLE IN THEM OR CLOSE TO THEM. INDICATE EACH TEN AS YOU COUNT THEM, A TOTAL COUNT AND YOUR LEVEL OF CONFIDENCE IN ITS ACCURACY. YOU HAVE UP TO 20 MINUTES. ANY QUESTIONS?

Explain the instructions as necessary, signal time and start. Announce time at 10 and 15 minutes.

Task 12. This problem will be given after Task 2 and uses the same imagery. Give the subject the target key sheet. Read the following instructions:

THE NEXT PROBLEM USES THE SAME IMAGERY AS THE LAST ONE. IT WILL BE MONOCULAR/STEREOSCOPIC. HAVING COUNTED ALL FORWARD VESSELS, NOW COUNT ANY OF THOSE HAVING ANY

OPEN HOLDS. INDICATE EACH TEN AS YOU COUNT THEM, A TOTAL, AND YOUR OVERALL LEVEL OF CONFIDENCE IN ITS ACCURACY. YOU WILL HAVE UP TO 20 MINUTES TO FINISH YOUR COUNT. ANY QUESTIONS?

Make sure the target type is understood, check time and start.

Task 13. Mount test photos in proper orientation and cover with a clean overlay. Give the subject a question sheet and submarine key. Read the following:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOUR TASK IS TO ANSWER EACH OF FOUR QUESTIONS IF POSSIBLE IN REGARD TO EACH OF THE NUMBERED VESSELS. GIVE ONLY THOSE ANSWERS WHICH THE IMAGERY SUPPORTS. DON'T GUESS. INDICATE YOUR CONFIDENCE IN EACH ANSWER. YOU WILL HAVE UP TO 30 MINUTES. ANY QUESTIONS?

Explain each question, if necessary, as it is given. Have the subject answer each question for all targets before moving to the following question. Record a confidence level for each answer given and the time when all answers to each question are recorded.

Task 14. Mount test photos in proper orientation, cover with an overlay, and give the subject a target diagram, and aircraft key. Read the following:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. IF POSSIBLE ANSWER EACH OF THE FIVE QUESTIONS TO BE ASKED FOR

EACH OF THE TEN NUMBERED AIRCRAFT. AVOID GUESSING, AND INDICATE YOUR CONFIDENCE IN EACH ANSWER YOU GIVE. YOU WILL HAVE UP TO 30 MINUTES. ANY QUESTIONS?

Clarify questions, if necessary, as they are given. Ask each question in regard to all aircraft before moving to the following question. Be sure to record confidence for <u>each answer</u> and elapsed time at completion of <u>each question</u>.

<u>Task 15</u>. Mount the test film, properly oriented (marginal data readable) on the light table. Locate the test grid over the film. Cover with clean shield. Read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOUR TASK IS TO STUDY THE AREA COVERED BY THE GRID AND IDENTIFY THE PREDOMINANT CATEGORY OF GROUND COVER IMAGED WITHIN DESIGNATED GRID SQUARES. SIX CATEGORIES ARE TO BE CONSIDERED: WOODED-TALL TREES, WOODED-SHRUBS, SCATTERED TREES, OPEN-UNPLOWED, OPEN-PLOWED, AND OTHER. STUDY THE FILM AND ANNOUNCE WHEN YOU ARE READY FOR QUESTIONS. PLEASE INDICATE A LEVEL OF CONFIDENCE FOR EACH REPLY. YOU WILL HAVE UP TO 15 MINUTES.

Announce time at 10 minutes.

<u>Task 16</u>. Mount the test film, properly oriented. Cover with a clean shield. Read the following instructions:

THIS IS A MONOCULAR/STEREOSCOPIC PROBLEM. YOUR TASK IS TO RATE THE GROUND COVER OF THE AREA WITHIN THE

OUTLINE. CONSIDER SIX CATEGORIES: WOODED-TALL TREES, WOODED-SHRUBS, SCATTERED TREES, OPEN-UNPLOWED, OPEN-PLOWED, AND OTHER. YOU WILL HAVE UP TO 30 MINUTES.

Announce time at 20 and 25 minutes. When the map is completed, place a scoring grid over it and read the following:

INDICATE THE PREDOMINANT GROUND COVER CATEGORY FOR EACH DESIGNATED GRID SQUARE AND A LEVEL OF CONFIDENCE FOR EACH REPLY.

COLOR RECONNAISSANCE TEST SUBJECT BIOGRAPHY

SUBJECT NUMBER: _____ NAME: _____ AGE: ____

EDUCATION: High School _____

College _____

Degrees/Majors _____/_____

_____/_____

_____/_____

MILITARY SERVICE: Dates _____ Service _____

_____ _____

Time In Reconnaissance/Intelligence Billets

_____

Reconnaissance/Intelligence Specialities

_____

CIVILIAN EXPERIENCE: In Reconnaissance/Intelligence Field _____

In Technical Assignments _____

In Supervisory Assignments _____

Percent of Time In Last Year Spent In Intelligence Imagery _____

COLOR RECONNAISSANCE TEST SCORE SHEET

SUBJECT NO. _____

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subj./Conf.	Error/F.A./Raw	Start/Response/Elapsed	Score Adjusted
TASK 1 (Parking Lots)		BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
" 30				
" 40				
Total	25			
TASK 2 (Ships)		BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
" 30				
" 40				
" 50				
" 60				
Total	43			
TASK 3 (Rare Tgts - Annapolis)		BW/Color	Mono/Stereo	Order _____
Nike Site	1			
Drydock	0			
Drydocks	2			
Underground Str.	1			
Aircraft	2			
Ramps	2			
Tree Ranges	1			
Total Count	8			
TASK 4 (Construction Sites)		BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
Total	8			
TASK 5 (Sampans)		BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
" 30				
" 40				
" 50				
" 60				
" 70				
Total	54			

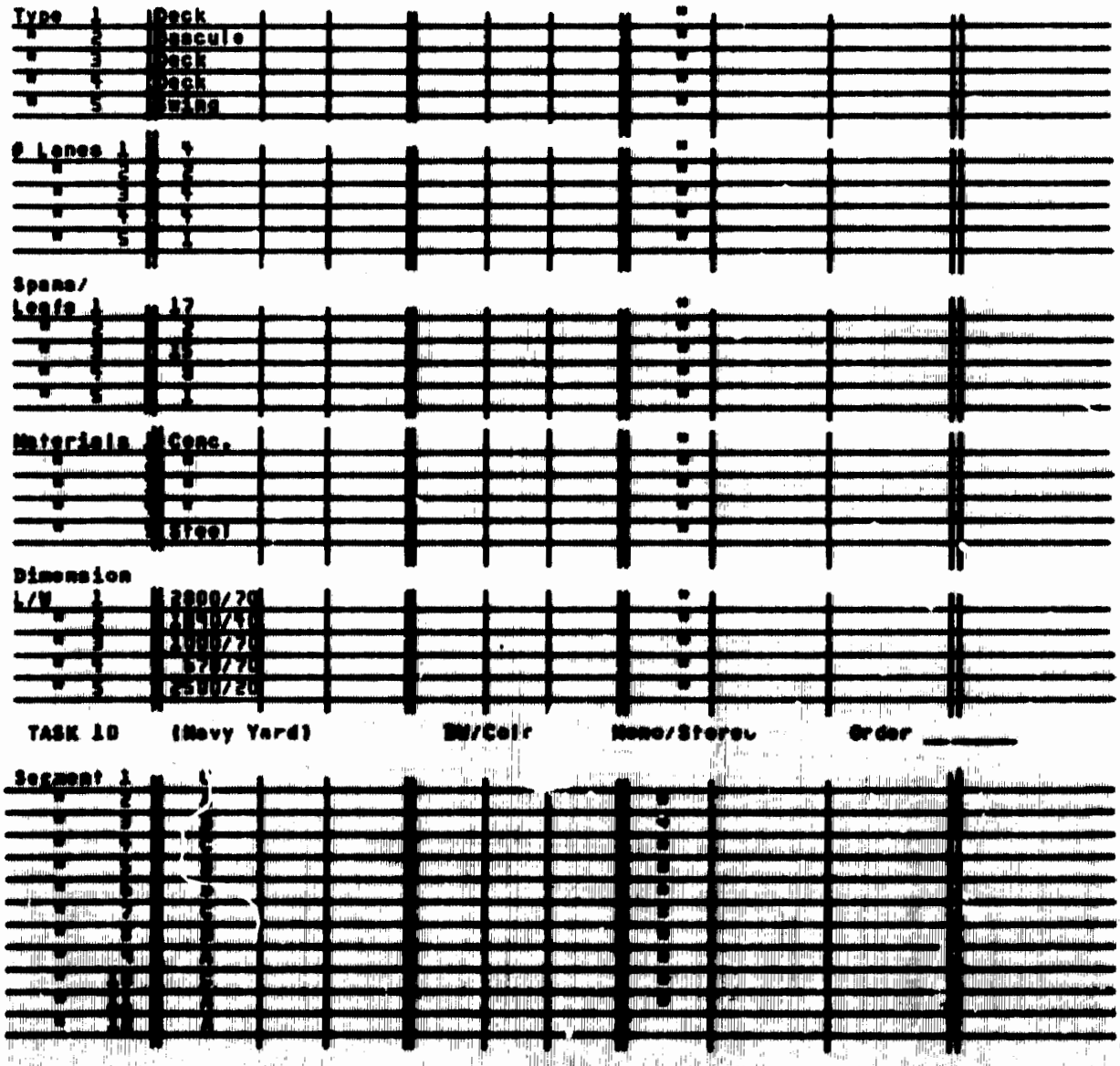
COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subj./Conf. Error/F.A./Raw		Start/Response/Elapsed	Score Adjusted
TASK 6	(Transmission Towers)	BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
" 30				
" 40				
" 50				
" 60				
" 70				
" 80				
" 90				
" 100				
" 110				
Total	106			
TASK 7	(Military Vehicles)	BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
Total	9			
TASK 8	(Water Buffalo)	BW/Color	Mono/Stereo	Order _____
Count 10				
" 20				
Total	8			
TASK 9	(Bridges)	BW/Color	Mono/Stereo	Order _____
Traffic 1	Road			
" 2	"			
" 3	"			
" 4	Rail			
Fixed/ Move				
"				
"				
"				
"				

COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subj./Conf.	Error/F.A./Rem.	Start/Response/Elapsed	Score Adjusted

TASK 9
(CONTINUED)



COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subj./Conf.	Error/F.A./Raw	Start/Response/Elapsed	Score Adjusted

TASK 10
(CONTINUED)

Cranes:				
Giant Hammerhead	1			
Revolving	24			
Overhead	5			
Floating	1			
Total Count	31			

TASK 11 (Manned Sampans) B&W/Color Mono/Stereo Order _____

Count 10				
" 20				
" 30				
Total	12			

TASK 12 (Ship Types) B&W/Color Mono/Stereo Order _____

Count 10				
" 20				
" 30				
Total	8			

TASK 13 (Submarines) B&W/Color Mono/Stereo Order _____

Mull -1	8			
" -2	6			
" -3	7			
" -4	7			
" -5	6			
" -6	7			
" -7	7			
" -8	7			
Tower -1	1/8			
" -2	2/8			
" -3	3/8			
" -4	4/8			
" -5	5/8			
" -6	6/8			
" -7	7/8			
" -8	8/8			

COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subl./Conf.	Error/F.A./Raw	Start/Response/Elapsed	Score Adjusted
TASK 13 (CONTINUED)				
Watches -1	W/O			
" -2	W			
" -3	W/O			
" -4	W			
" -5	W			
" -6	W			
" -7	W			
" -8	W/O			
Length-1	235'			
" -2	380'			
" -3	280'			
" -4	380'			
" -5	380'			
" -6	350'			
" -7	350'			
" -8	350'			
Type -1				
" -2				
" -3				
" -4				
" -5				
" -6				
" -7				
" -8				
TASK 14	(Aircraft)	BW/Color	Mono/Stereo	Order _____
Wing -1	T/T			
" -2	B/T			
" -3	[illegible]			
" -4	T/B			
" -5	[illegible]			
" -6	B/T			
" -7	T/T			
" -8	[illegible]			
" -9	T/B			
" -1	B/T			

COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subj./Conf.	Error/F.A./Raw	Start/Response/Elapsed	Score Adjusted
TASK 14 (CONTINUED)				
No. Engines - 1	2			
" - 2	2			
" - 3	2			
" - 4	2			
" - 5	4			
" - 6	4			
" - 7	4			
" - 8	3			
" - 9	4			
" -10	4			
Engine Type - 1	P			
" - 2	TP			
" - 3	J			
" - 4	P			
" - 5	J			
" - 6	TP			
" - 7	P			
" - 8	J			
" - 9	P			
" -10	TP			
Dynamics - 1	PROP.			
" - 2	PROP.			
" - 3	PROP.			
" - 4	PROP.			
" - 5	PROP.			
" - 6	JET			
" - 7	JET/F			
" - 8	LOAD			
" - 9	TANK			
" -10	LOAD			
Aircraft - 1	CV250			
" - 2	FIGHTER			
" - 3	DA320			
" - 4	MC-1			
" - 5	LOCK C-130			
" - 6	ELECTRA			
" - 7	MC-6			
" - 8	B727			
" - 9	B707			
" -10	ELECTRA			

COLOR RECONNAISSANCE TEST SCORE SHEET (CONT)

QUERY	RESPONSES	SCORE	TIME	
	Correct/Subl./Conf. Error/F.A./Rep.		Start/Response/Elapsed	Score Adjusted

TASK 15 (Ground Cover) BW/Color Mono/Stereo Order _____

Square		
	A-1	5
	A-3	5
	A-5	5
	B-2	5
	B-4	5
	B-6	5
	C-1	5
	C-3	5
	C-5	5
	D-2	1
	D-4	2
	D-6	5
	E-1	5
	E-3	1
	E-5	5
	F-2	5
	F-4	5
	F-6	5

TASK 16 (Ground Cover) BW/Color Mono/Stereo Order _____

Square		
	A-2	5
	A-4	5
	B-1	1
	B-3	5
	B-5	5
	C-2	2
	C-4	5
	D-1	5
	D-3	5
	D-5	5
	E-2	5
	E-4	1

APPENDIX B

TEST ANALYSIS DATA
(TYPICAL SAMPLES)

OVERALL TEST
BASIC
RAW SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	67.16	MN	67.18	MN	67.17
	S	23.35	S	26.08	S	24.69
	N	96	N	96	N	192
STEREO	MN	65.98	MN	68.66	MN	66.32
	S	23.88	S	24.82	S	24.40
	N	96	N	96	N	192
TOTAL	MN	66.57	MN	67.92	MN	66.74
	S	23.61	S	25.40	S	24.52
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	69.683	1	69.683	0.1156
PAN/COLOR	531.665	1	531.665	0.8822
RESIDUAL	229615.725	381	602.666	
TOTAL	230217.074	383		

OVERALL TEST
CONFIDENCE-WEIGHTED
RAW SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	51.10	MN	52.02	MN	51.56
	S	24.34	S	26.71	S	25.49
	N	96	N	96	N	192
STEREO	MN	47.85	MN	51.09	MN	49.47
	S	22.54	S	26.90	S	24.80
	N	96	N	96	N	192
TOTAL	MN	49.48	MN	51.55	MN	50.52
	S	23.45	S	26.74	S	25.14
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	418.980	1	418.980	0.6618
PAN/COLOR	414.765	1	414.765	0.6553
RESIDUAL	241153.159	381	632.948	
TOTAL	241986.824	383		

OVERALL TEST
BASIC
ADJUSTED SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	98.49	MN	107.28	MN	102.89
	S	35.50	S	41.42	S	38.73
	N	96	N	96	N	192
STEREO	MN	98.02	MN	103.57	MN	100.80
	S	38.29	S	37.64	S	37.97
	N	96	N	96	N	192
TOTAL	MN	98.26	MN	105.43	MN	101.84
	S	36.83	S	39.52	S	38.32
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	414.356	1	414.356	0.2862
PAN/COLOR	4959.916	1	4959.916	3.3934
RESIDUAL	556913.661	381	1461.758	
TOTAL	562287.933	383		

OVERALL TEST
CONFIDENCE-WEIGHTED
ADJUS~ SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	82.44	MN	92.11	MN	87.28
	S	34.65	S	41.23	S	38.29
	N	96	N	96	N	192
STEREO	MN	81.89	MN	86.01	MN	83.95
	S	35.58	S	37.13	S	36.35
	N	96	N	96	N	192
TOTAL	MN	82.16	MN	89.06	MN	85.61
	S	35.03	S	39.25	S	37.31
	N	192	N	192	N	384

SOURCE	SS	DF	MS	F
[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	381	[illegible]	
TOTAL	[illegible]	383		

OVERALL TEST
BASIC
ACCURACY SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	94.34	MN	92.79	MN	93.56
	S	16.53	S	21.74	S	19.27
	N	96	N	96	N	192
STEREO	MN	94.58	MN	92.73	MN	93.66
	S	15.08	S	21.56	S	18.58
	N	96	N	96	N	192
TOTAL	MN	94.46	MN	92.76	MN	93.61
	S	15.78	S	21.59	S	18.90
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	0.625	1	0.625	0.0025
PAN/COLOR	275.367	1	275.367	0.7756
RESIDUAL	136578.125	381	358.475	
TOTAL	136856.117	383		

OVERALL TEST
CONFIDENCE-WEIGHTED
ACCURACY SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	61.51	MN	62.16	MN	61.84
	S	22.66	S	25.50	S	24.06
	N	96	N	96	N	192
STEREO	MN	60.61	MN	58.55	MN	60.08
	S	22.73	S	26.45	S	24.60
	N	96	N	96	N	192
TOTAL	MN	61.06	MN	60.35	MN	60.96
	S	22.64	S	25.94	S	24.32
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	395.737	1	395.737	0.4882
PAN/COLOR	4.297	1	4.297	0.0071
RESIDUAL	226161.655	381	593.600	
TOTAL	226461.623	383		

OVERALL TEST
BASIC
COMPLETENESS SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	71.31	MN	70.21	MN	70.76
	S	22.45	S	26.26	S	24.37
	N	96	N	96	N	192
STEREO	MN	67.99	MN	71.45	MN	69.72
	S	22.64	S	25.08	S	23.89
	N	96	N	96	N	192
TOTAL	MN	69.65	MN	70.83	MN	70.24
	S	22.55	S	25.62	S	24.11
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	102.958	1	102.958	0.1764
PAN/COLOR	133.546	1	133.546	0.2288
RESIDUAL	222345.141	381	583.583	
TOTAL	222581.645	383		

OVERALL TEST
CONFIDENCE-WEIGHTED
COMPLETENESS SCORES

Analysis of Variance

MONO	MN	53.76	MN	53.99	MN	53.87
	S	23.76	S	26.62	S	25.16
	N	96	N	96	N	192
STEREO	MN	50.71	MN	53.36	MN	52.04
	S	21.51	S	26.48	S	24.10
	N	96	N	96	N	192
TOTAL	MN	52.23	MN	53.68	MN	52.95
	S	22.66	S	26.48	S	24.62
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	324.461	1	324.461	0.5336
DAM/CHLOE	199.575	1	199.575	0.5282
RESIDUAL	251672.776	381	660.685	
TOTAL	252196.812	383		

OVERALL TEST
BASIC
SPEED SCORES

Analysis of Variance

		PAN		COLOR		TOTAL
MONO	MN	31.33	MN	40.10	MN	35.72
	S	23.14	S	22.73	S	23.30
	N	96	N	96	N	192
STEREO	MN	34.04	MN	34.92	MN	34.48
	S	22.14	S	22.39	S	22.21
	N	96	N	96	N	192
TOTAL	MN	32.69	MN	37.51	MN	35.10
	S	22.63	S	22.65	S	22.74
	N	192	N	192	N	384

SOURCE	SS	DF	VAR. EST.	F
MONO/STEREO	146.187	1	146.187	0.2854
PAN/COLOR	2330.359	1	2330.359	4.5488
RESIDUAL	195672.930	381	513.576	
TOTAL	198004.446	383		